Golder Associates Corporation

1809 North Mill Street, Suite C
Naperville, IL USA 60563
Telephone (708) 357-2066
Fax (708) 357-2330

Golder Associates

REPORT ON

PRELIMINARY ECOLOGICAL RISK ASSESSMENT PHASE I REMEDIAL INVESTIGATION OF THE MISCELLANEOUS AREAS OPERABLE UNIT

CRAB ORCHARD NATIONAL WILDLIFE REFUGE MARION, ILLINOIS

DISTRIBUTION:

4 copies	Mr. Nan Gowda, U.S. Environmental Protection Agency, Region 5
7 copies	Mr. Stephen Nussbaum, Illinois Environmental Protection Agency
4 copies	Mr. Eugene Liu, U.S. Army Corps of Engineers, Omaha District
1 copy	Mr. Frank Fisher, U.S. Army Corps of Engineers, Omaha District
3 copies	Mr. Mark Sattelberg, U.S. Fish and Wildlife Service
1 copy	Mr. Kevin Kelly, Montgomery Watson
1 copy	Ms. Julia Halsne, Montgomery Watson
3 copies	Golder Associates

December 1993

932-7203

00000302

1.0 INTRODUCTION

This report presents the preliminary ecological risk assessment of the Phase-I Remedial Investigation (RI) of the Miscellaneous Areas Operable Unit (Misc AOU) on Crab Orchard National Wildlife Refuge, located near Marion, Illinois (Figure 1). The Phase I RI report of the Misc AOU includes 24 sites (Figure 2), as listed in Table 1 (23 Misc AOU sites and Site 22A).

The purpose of this preliminary ecological risk assessment is to determine which of the Misc AOU sites may safely be assumed to pose no threat to ecological receptors and which sites may require additional ecological work. Following U.S. Environmental Protection Agency - Region V guidelines, this preliminary evaluation is not intended to be a detailed quantitative assessment of potential risks associated with exposure of individual species to the constituents of concern. Rather, the preliminary screening is a "desk-top" predictive assessment that uses data from site characterizations, information acquired from literature and local experts, and relevant benchmark values or "applicable or relevant and appropriate requirements" (ARARs) to quickly determine whether it can be safely assumed that site contaminants (where determined to be present) pose no threat to ecological receptors.

This preliminary screening is then used to determine the need for additional studies and to provide direction for those studies if they are deemed necessary. Conservative assumptions are used throughout this analysis to ensure a high degree of confidence in conclusions which indicate that a particular site poses little or no ecological risk. This process allows sites with little or no ecological risk to be quickly and accurately screened from requiring additional ecological work.

The technical guidance for this ecological risk assessment comes from several sources including: the Interim Final Risk Assessment Guidance for Superfund: Volume II Environmental Evaluation Manual (U.S. EPA 1989a); U.S. EPA Region V Regional Guidance for Conducting Ecological Assessments; Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (U.S. EPA 1989b); and the U.S. EPA Framework for Ecological Risk Assessment (U.S. EPA 1992). Numerous other references were used for this report and are included in the literature cited section.

The principal tasks for ecological risk assessment of each site include the following: (1) identifying the constituents of concern; (2) identifying and conceptually analyzing environmental receptors/pathways, (3) estimating exposure point concentrations and exposure doses for the constituents of concern; (4) identifying environmental toxicity; and (5) characterizing ecological risk.

This report includes five major components:

- site characterization,
- exposure analysis,
- toxicity assessment
- risk characterization,
- recommendations.

The site characterization includes: (1) descriptions of aquatic and terrestrial habitats and species associated with each site, including information on threatened or endangered species and special habitats of concern; (2) a summary of available information concerning the source, nature, and extent of contamination; (3) a list of potential constituents of concern; and (4) a description of any observed/reported adverse effects of site constituents to biota.

The exposure analysis presents the constituent migration pathways, exposure routes, and estimated exposure concentrations for the ecological receptors. Site characteristics affecting potential migration and exposure pathways are integrated to develop a conceptual model for the site and to identify exposure pathways and receptors for further evaluation.

The toxicity assessment documents environmental toxicity information for the constituents of concern. This assessment uses published criteria and guidelines to produce a technical summary of the constituents' known environmental effects.

Risk characterization integrates the information obtained in the toxicity and exposure assessments to evaluate the potential for adverse environmental effects at each site. Potential ecological risks are then identified by comparing estimated exposure concentrations with environmental toxicity criteria.

Finally, recommendations for additional work are presented. These recommendations are based on the preliminary screening assessment. In general, if the preliminary screening indicates ecological effects from site contaminants are at least possible, then additional field studies must be considered.

2.0 SITE CHARACTERIZATION

The purposes of this section are to: (1) describe the existing aquatic and terrestrial habitats in the study area and their associated species; (2) summarize available information on source areas, constituents and migration pathways; and (3) describe known or suspected effects of contaminants that were observed or reported. This section provides the foundation for the subsequent sections that assess exposure and risk to aquatic and terrestrial communities.

The following tasks were performed to complete the site characterization.

- Reviewed existing information on the environmental and ecological resources in the study area vicinity including general refuge information (e.g., Crab Orchard NWR's Annual Narrative), and species-specific research projects (e.g., theses from Southern Illinois University).
- Reviewed publications prepared by the Illinois Endangered Species Protection Board (i.e, Herkert 1991, Herkert 1992) on the status and distribution of endangered and threatened species in Illinois.
- Interviewed U.S. FWS staff to identify any special or sensitive ecological resources within the vicinity of the study area.
- Utilized existing reports and cover maps to aid in characterizing the study area.
- Summarized available information on the source, nature and extent of site-related constituents and potential routes of constituent migration.
- Conducted field reconnaissance investigations of each site to record any visible signs of contamination and ecological impairment.

2.1 Site Setting

2.1.1 Climate

A summary of the climate in the southern Illinois region was provided in the Draft Phase I RI report (Golder Associates 1993) and in the Preliminary Risk Assessment for the Explosives/Munitions Manufacturing Areas (ESE 1993). Generally, the climate is classified as humid continental, characterized by seasonal fluctuations in temperature and precipitation (Booker Associates, Inc. 1978 in ESE 1993). Historically, the early spring months receive the most precipitation and the summer/early fall months receive the least. The average rainfall is 43.5 inches. July is the hottest month with a mean temperature of 80°F and January is the coolest month with a mean temperature of 34.0°F. Windrose information for Carbondale for the period of February 1990 to December 1991 (NAOA, 1992) indicates the predominant annual wild direction to be from South-Southwest at an average velocity of approximately 12 miles per hour with calm winds (<1.0 mph) for approximately 2% of the year.

2.1.2 Topography and Soils

Hawkins (1967 in ESE 1993) characterized the topography of the refuge area as generally of low relief, with wide valleys, and a well-developed drainage system. Soils are of the Hosmer silt loam type, typically shallow, infertile soil developed from loess. Site-specific information on topography is provided in section 2.2.

2.1.3 Geology

The Geology of the area was briefly described by O'Brien and Gere (1988). The bedrock which underlies the soil sequence consists of Pennsylvanian Age sandstones and shales known as the Carbonale Formation (American Association of Petroleum Geologists 1965 in O'Brien and Gere 1988). The upper portion of the bedrock sequence, penetrated by split spoon sampling, consists predominantly of sandstone. The area is situated near the southern limit of the Illinois basin structural feature. As a result, the bedrock in the area dips gently to the north and northeast.

2.1.4 General Habitat Characterization

The Refuge consists of 43,500 acres located in southern Illinois near the cities of Marion, Carterville and Carbondale (Figure 1). The Refuge is located primarily within Williamson County with portions extending into neighboring Jackson, Union and Johnson Counties. All of the Misc AOU sites are located in Williamson County. Detailed site descriptions are provided in section 2.2.

The Refuge, established after World War II from an Illinois ordinance plant, is composed of a mosaic of interspersed habitat types. These types include tracts of second-growth and cut-over forests, old fields, open water, industrial facilities and agricultural lands; ESE (1993) provided a detailed synopsis of these habitat types. The aerial coverage of each habitat type consists of approximately 9,300 acres of open water, 15,200 acres of forests (including 3,000 acres of pine plantations), 11,500 acres of old fields, 5,000 acres of agricultural lands, and 1,500 acres of industrial facilities (U.S. FWS 1992). Below, we provide a brief summary of each habitat type.

2.1.4.1 Forests

The forests on the refuge can be separated into two categories: deciduous and mixed deciduous-coniferous.

Deciduous Forest

The deciduous forests are best classified as mesic, mixed hardwoods. The younger seral stages include shrubs (such as Rosa and Rubus) and Sassafras saplings. These species are succeeded by shade-tolerant hardwoods which mature in even-aged stands (Urban 1981). On well-drained uplands, these mature stands are generally dominated by mixed oak (e.g., white oak, northern red oak) and hickory species. On wetter sites and in bottomland communities, the mature stands are generally dominated by oaks (e.g., swamp chestnut oak), black willow, cottonwood, sycamore, red maple and silver maple (ESE 1993). Several study sites (e.g., 7, 9, 10, 12, 20) were located in, and adjacent to upland and bottomland hardwood communities.

Mixed Deciduous-Coniferous Forest

This forest type consists of relatively scattered and localized communities (ESE 1993). Plant species found in these areas include deciduous species described in the deciduous forest habitat type as well as a number of coniferous species which may include scotch pine, shortleaf pine, and loblolly pine. None of the study sites were located in this habitat type.

2.1.4.2 Old Fields

Old fields are scattered throughout the study area generally in areas previously cleared for industry or agriculture. Dominant vegetation of old field habitat types on the Refuge is variable, depending on the time since the site was last disturbed. Recently disturbed old fields are dominated by herbaceous species consisting of a variety of forbs (e.g., daisy, fleabane, goldenrod, thistle) and grasses (brome, fescue, timothy, bluegrass) (ESE 1993). Woody species such as black cherry, autumn olive, and persimmon are usually scattered in these fields. Older fields are usually dominated by multiflora rose, black cherry, persimmon, autumn olive, staghorn sumac, roughleaf dogwood, white ash and coralberry (ESE 1993).

2.1.4.3 Open Water

Areas on the Refuge in this habitat type include Devil's Kitchen Lake, Little Grassy Lake and Crab Orchard Lake, its tributaries and numerous small impoundments. Crab Orchard is 2,796 ha reservoir with a mean depth of 3 m and a maximum depth of 10 m (Kohler et al. 1990). Crab Orchard Lake is heavily utilized for recreational fishing and contains a number of game fish including largemouth bass, yellow bass, white bass, bluegill, and white-striped bass hybrids (ESE 1993).

Crab Orchard Lake catches runoff from all study sites. Moreover, runoff into Crab Orchard Lake is derived from 196 square miles of watershed (Stall et al. 1954 in Hite and King 1977). Sixty-seven percent of the Crab Orchard Creek Basin runoff empties into Crab Orchard Lake (Hite and King 1977). Hite and King (1977) classified land use in this basin into four categories: cropland (33.7% of watershed), pastureland (11%), forest land (19.5%), and other land (including urban areas, industrial areas, coal mines, state and federal lands, and farmsteads) (35.8%).

2.1.4.4 Industrial Facilities

Several of the study sites were within the confines of active or remnant industrial facilities. Vegetation associated with these sites usually consists of manicured lawns or lawn-like fields that are cut on a regular basis. On many sites, deciduous trees are scattered throughout the lawns.

2.1.4.5 Agricultural Fields

Agricultural fields are a common element within the landscape of the study area. These fields are pasture lands or croplands, and are generally found on relatively flat terrain bordered by old fields, treed fencerows, or forests. Historically, two classes of crop have been planted within the refuge: hay and row crops (ESE 1993). Hayfields are typically planted in red clover and grasses. Corn is the primary crop in terms of total planted acreage, but milo, soybean and winter wheat are also important row crops (ESE 1993).

2.1.5 Identification of Special/Sensitive Resources

The presence of threatened or endangered species or rare natural communities within, adjacent to, or downstream from study sites were examined as part of this investigation. Published information was derived from U.S. FWS, Illinois Endangered Species Protection Board and ESE (1993); no field surveys were conducted by Golder Associates ecologists to search for such species of resources. Based on the reviewed literature, a number of Illinois state-listed and federal-listed faunal species may occur within the Refuge (Table 2). However, after reviewing the literature and after the field reconnaissance and discussions with Refuge personnel (e.g., John Maybery, wildlife biologist - U.S. FWS), we concluded that none of the study sites warranted concern for the species listed in Table 2.

Threatened and endangered plant surveys were not undertaken as part of the Preliminary Ecological Risk Assessment because vegetation did not appear to be negatively impacted by contaminants at any of the sites.

2.2 Site Description/Species Association

Ecological field reconnaissances were conducted July 22-25, 1993, by two Golder Associates scientists, an aquatic ecologist and a terrestrial ecologist. During this phase of the project, 18 sites were visited, and site walkovers were conducted at all sites. At each site, photographs were taken and information was gathered such as site-specific topography, qualitative plant community descriptions, terrestrial animal observations [direct and indirect (i.e., tracks, droppings)] and aquatic animal observations. Additionally, all bird species heard or seen in the vicinity of each site were recorded. We recognized that the timing (both time of year and time of day) of the site investigations would not provide a comprehensive species list of birds for each site. Therefore, a list of common bird species likely to use each site was developed through the combination of field observations, published literature, and the personal knowledge of the terrestrial ecologist.

The above information was integrated with published literature obtained from the Crab Orchard Refuge library. The objective of this investigation was to develop a better understanding of the functioning ecosystem at each of the sites so that contaminant transport pathways and target species could be identified.

The site descriptions provided below are the result of the assimilation of the literature review and the field reconnaissance. The vegetative species listed below represent dominant or common species at each site. Animal species associations were derived by combining field observations with published literature and historical refuge observations. Refer to Appendix I for a more comprehensive listing of the common species of vegetation, birds, mammals and herpetofauna associated with each habitat.

In addition to developing an ecological description at each site, the field ecologists recorded any noticeable signs of potential site contamination. Before the field work began, noticeable signs of potential contamination were defined to include: bare spots where vegetation was absent, stressed or unusually sparse; dead or moribund animals; soil or sediment discoloration; water discoloration; and chemical odors.

2.2.1 Site 7 - D Area Southeast Drainage Channel

Site 7 of Area D is located at the eastern edge of the Olin facility in Area D, approximately 250 m south of the east - west paved road (Figure 3). The facility is currently operated by Olin to manufacture explosives.

This site includes a segment of an intermittent stream that flows north to south within a portion of the Olin facility. The stream originates about 650 m upstream of the site, enters the fenced area on the east side of the Olin operation and exits on the same side approximately 100 meters (m) downstream. This stream is fed, in part, by runoff from the Olin facility. After leaving the Olin facility, the stream flows south through deciduous forests, including a bottomland hardwood system and eventually enters Crab Orchard Lake. The total distance that runoff from the site must travel before reaching Crab Orchard Lake is about 2 km (Figure 4).

At the time of the site visit, the stream was 0.5-2 m wide and characterized by relatively low flow, a maximum depth of 30 cm, and sand/gravel substrates overlying soft clay. There was no evidence of flooding. Algal growth was limited in the stream channel. Aquatic fauna observed at the site included southern leopard frogs, bullfrogs (see Appendix II for scientific names of vertebrate species), crayfish, water boatmen (Corixidae) and water striders (Gerridae). Other, likely fauna based on stream characteristics include the larvae of chironomid midges and mosquitoes (Culicidae) in stagnant ponds. No evidence of contamination or adverse ecological effects were found in the stream channel. Several plastic bag fragments and containers were observed along the bank of the stream.

Within the Olin facility, the general habitat characterization is that of an industrial facility (see 2.1.3.4). The uplands consist primarily of grasses, legumes and composites. These uplands are regularly mowed, and provide limited wildlife habitat. However, adjacent to the perennial stream, sumac, blackberry, nettles and poison ivy were abundant. Outside of and downstream from the Olin facility, the stream flows through a deciduous forest. The dominant tree species within the forest are of pin oak, northern red oak, and hickory species in the well-drained sites and overcup oak, swamp chestnut oak, eastern cottonwood and red maple on the poorly drained sites. Dominant understory species include sumac, bramble and elm, and dominant herbaceous vegetation includes grasses, poison ivy and stinging nettle.

Predominant bird species observed in the uplands within the Olin facility during site reconnaissance were of eastern meadowlark, american robin, eastern bluebird, and northern mockingbird. Bird species observed in the forest community included house wren, northern cardinal, rufous-sided towhee, and great-crested flycatcher.

No mammal were observed during the site reconnaissance, but common species that would likely use the upland habitats within the Olin facility include (but may not be limited to) white-tailed deer, eastern cottontail rabbit, eastern mole and deer mouse. Species that likely inhabit the adjacent forest community include white-tailed deer, eastern cottontail, deer mouse, fox squirrel and gray squirrel.

Southern leopard frog and bullfrog were observed in and adjacent to the stream. No other herpetofauna were observed in the area, but species that would likely use the uplands adjacent to the stream within the Olin facility include prairie kingsnake, eastern garter snake and eastern yellow-bellied racer. Species that would likely use the uplands adjacent to the stream in the forest community include black rat snake, gray treefrog, and eastern box turtle. There were no visible signs of contamination on any of the uplands within the site.

2.2.2 Site 7A - D Area North Lawn

Site 7A of Area D is located at the northwest corner of the Olin facility, adjacent to the east-west paved road (Figure 3). The site consists of a 3-acre lawn. Currently, Olin manufactures explosives and air bag detonators in the buildings adjacent to the site. The site gently drains to the north and west. Outside the Olin facility, the drainage flows toward a small woodlot, under a paved road, into an intermittent stream (within a bottomland hardwood community) and eventually into Crab Orchard Lake a total distance of less than 1.5 km (Figure 4).

No permanent aquatic habitats were evident at this industrial site. A drainage ditch outside the fence and a small drain parallel to the ditch approximately 250 m to the south, drains the northwestern part of the site occupied by Olin's operations. These drains merge, forming the intermittent stream that flows towards the west, eventually discharging into Crab Orchard Lake. No flow was present in the stream at the time of the site visit. Approximately 200 m downstream from Site 7A, the stream was 1 m wide with a clay bottom. Maximum depth of pools was 20 cm, and the banks were covered with very dense vegetation. There was no evidence of flooding. Algal growth was sparse in the stream channel. Although aquatic organisms were not observed in the stream, its probable dominant fauna include aquatic midge larvae (Chironomidae), mosquito larvae

(Culicidae), crayfish snails and frogs. No indication of contamination or adverse ecological effects were noted in the aquatic habitats.

Within the Olin facility, the general habitat characterization is that of an industrial facility that is reverting back to a native prairie. The uplands are composed primarily of grasses, legumes and composites. The site is periodically mowed to encourage native prairie species (C. DeMille, pers. commun.). Indeed, the vegetation communities appeared to be reverting to native prairie. Several small (i.e., <10 m^2), low areas were observed within the site boundary. These areas were well-vegetated with moist soil plants such as Carex sp., Panicum sp. and Eleocharis sp. and likely contain standing water only after periods of heavy rain. The dominant tree species in the adjacent woodlot are southern red oak, white oak, pignut hickory, shortleaf pine and mulberry on well-drained sites, and willow and cottonwood on the poorly drained sites.

Avian species observed within the site included eastern meadowlark, northern bobwhite, and red-winged blackbird. Other locally common species that might use the site during the breeding season include dickcissel and field sparrow. Bird species observed in the adjacent woodlot included northern mockingbird, northern cardinal, northern bobwhite, yellow-breasted chat, blue jay, indigo bunting, field sparrow and cedar waxwing (also see Appendix I).

No mammals were observed during the field reconnaissance. However, species that would likely use the prairie habitat include white-tailed deer, eastern cottontail, eastern mole, deer mouse and prairie vole. Mammalian species that would likely use the adjacent forest community include white-tailed deer, deer mouse, white-footed mouse, fox squirrel and eastern cottontail (also see Appendix I).

No herpetofauna were observed in the area, but species that would likely use the prairie habitats within the Olin facility include prairie kingsnake, eastern garter snake and eastern yellow-bellied racer. Species that would likely use the adjacent forest community include black rat snake, gray treefrog, and eastern box turtle.

There were no visible signs of contamination on any of the uplands within the site.

2.2.3 Site 8 - D Area Southwest Drainage Channel

Site 8 is located within the Olin facility near the center of Area D (Figure 3). The facility is currently operated by Olin to manufacture explosives.

This site includes a segment of a perennial stream that flows to the southwest. This stream originates on the Olin facility, apparently as industrial discharge. During storms this stream carries surface runoff from the central portion of the Olin facility downstream and off-site. After leaving the Olin facility, the stream flows southwest, through deciduous forests, including a bottomland hardwood system and eventually enters into Crab Orchard Lake in less than 1.5 km (Figure 4).

The stream was 30-50 cm wide and 10 cm deep with a low flow rate, and was surrounded by abundant vegetation such as sedges and bulrushes. There was no evidence of flooding. Bottom substrates were predominantly clay, occasionally anoxic, and were covered with moderate to abundant growth of green filamentous algae (Cladophora). Visible fauna included southern leopard frogs, aquatic snails (Pulmonata) and water striders (Gerridae). Moderate numbers of crayfish burrows were also seen. Additional likely fauna include larvae of chironomid midges and mosquitoes (Culicidae) in stagnant pools. No evidence of contamination or adverse ecological effects were found in the stream.

Within the Olin facility, the upland habitat is similar to that of Site 7 and is composed primarily of grasses, legumes and composites. As with Site 7, this site is periodically mowed to encourage native prairie species. There are a few mature pin oak, sugar maple and elm scattered throughout the uplands adjacent to the drainage.

Avian species observed in the uplands within the Olin facility during site reconnaissance consisted of eastern meadowlark, dickcissel, and red-winged blackbird. Other locally common species that should use the site during the breeding season include american robin, eastern bluebird and field sparrow (also see Appendix I). Bird species observed in the adjacent forest community included blue grosbeak, yellow-billed cuckoo, and european starling.

White-tailed deer tracks and raccoon and coyote droppings were observed along the drainage within the Olin facility. Other common mammals that likely use the area include eastern cottontail, eastern mole and deer mouse. Species that likely inhabit the adjacent forest community include white-tailed deer, eastern cottontail, deer mouse, fox squirrel and gray squirrel (Appendix I).

Southern leopard frogs were observed in and adjacent to the perennial stream. No other herpetofauna were observed in the area, but species that would likely use the uplands adjacent to the perennial stream within the Olin facility include prairie kingsnake, eastern garter snake and eastern yellow-bellied racer. Species that would likely use the uplands adjacent to the perennial stream in the forest community include black rat snake, gray treefrog, and eastern box turtle (Appendix I).

There were no visible signs of contaminants on any of the upland areas within the site.

2.2.4 Site 9 - P Area (North) Northwest Drainage Channel

The P Area was originally used by Universal Match while operating under a contract to the DOD. Their operations ceased after a large explosion (O'Brien & Gere 1988). Area P is now used by Olin for research and development and the manufacturing of ammunition.

Site 9 of Area P is located about 150 m northwest of the Olin facility (Figure 5). This site is composed of a perennial stream situated in a bottomland hardwood community. The stream carries surface water run-off from Area P and portions of Area D to Crab Orchard Lake. Moreover, Sites 7, 11A and 20 are upstream from this site.

Site 9 is located upstream (northeast) from where the perennial stream crosses the paved road. From the road, the stream flows southwest, gradually increasing in width and depth until it empties into a beaver pond approximately 200 m south of the road. This beaver pond in turn drains directly into Crab Orchard Lake. Overall, the total distance that runoff from the site would travel before reaching Crab Orchard lake is less than 1 km (Figure 4).

The perennial stream sampled at this site was 1-2 m wide and well shaded. It originates about 2000 m from the site. Maximum depth in pools was 30 cm and current velocity was low. Wooden debris scattered along the banks suggest this stream periodically floods. Stream bank vegetation was sparse and algal growth was minimal within the channel. Bottom substrates consisted of clay overlain by small gravel and sand. Stream invertebrate fauna observed at the site included water striders (Gerridae) and crayfish. In addition, larvae of chironomid midges and mosquitoes are also likely to occur in the stream. Numerous frogs (bull frogs and southern leopard frogs) were observed in the vicinity of the site. No evidence of contamination or adverse ecological effects were observed in the stream.

The dominant vegetation of the site is characteristic of a mature bottomland hardwood community. The dense overstory is dominated by red maple, swamp chestnut oak and cottonwood in the lower areas and sycamore and northern red oak on the higher elevations. The understory is lush, and dominated by herbaceous and woody vegetation. Dominant herbaceous vegetation included nettles, poison ivy, day flowers and various grasses. Dominant woody understory species included sassafras, elm, and young red maple.

The avian species observed in the vicinity during the field reconnaissance included northern bobwhite, eastern wood-peewee, eastern phoebe, and red-headed woodpecker. Other common woodland species that likely use the area during the breeding season include blue jay, downy woodpecker, prothonotary warbler, louisiana waterthrush, northern parula, yellow-billed cuckoo, red-eyed vireo and wood thrush (also see Appendix I).

White-tailed deer tracks were abundant along the perennial stream and fox squirrels were heard in the overstory during the field reconnaissance. Other common mammals that likely use the area include gray squirrel, least shrew, and raccoon (also see Appendix I).

Southern leopard frog and bullfrog were the only herpetofauna observed during the field reconnaissance. However, other herpetofauna that would likely use the bottomland hardwood community include black rat snake, gray treefrog, and eastern box turtle (Appendix I).

No visible signs of contamination were evident in the uplands at the site.

2.2.5 Site 10 - P Area (North) North Drainage Channel

Site 10 includes a perennial stream downstream from Sites 7, 9, 11A and 20, and the upper reaches of a beaver pond, which drains directly into Crab Orchard Lake (Figure 5). The site is located within a bottomland hardwood community. Overall, the total distance that surface runoff must travel from this site before reaching Crab Orchard lake is less than 1 km (Figure 4).

This site contains the immediate downstream reaches of the stream draining Site 9. The stream channel was considerably wider (3-7 m) and deeper (50-100 cm) than at Site 9, and no flow was evident. There was no evidence of flooding at this site. The stream was well shaded, with limited algal growth and moderate stream bank vegetation. The water was turbid and bottom substrates consisted predominantly of soft clay. In addition to aquatic fauna present or likely to be present at Site 9, groups of small fish (likely Centrarchidae) were also observed. No evidence of contamination or adverse ecological effects were noted in the aquatic habitats.

The dominant vegetation of this bottomland hardwood community is similar to that of site 9. Specifically, the overstory of mature deciduous hardwoods is dominated by red maple, swamp chestnut oak and cottonwood in the lower areas and sycamore and northern red oak on the higher elevations. The understory is more dense than at site 9, but with similar species. Dominant herbaceous vegetation includes nettles, poison ivy, day flowers and various grasses. Dominant woody understory species include sassafras, elm, and young red maple.

Bird species recorded during the field reconnaissance included eastern wood-peewee, red-headed woodpecker, red-eyed vireo, blue jay, rufous-sided towhee, yellow-billed cuckoo and common grackle. Other common woodland species that likely use the area during the breeding season include downy woodpecker, prothonotary warbler, louisiana waterthrush, northern parula, and wood thrush (Appendix I).

Fox squirrels were the only mammals observed during the field reconnaissance. However, deer tracks and beaver signs (tracks and fresh cuttings) were abundant along the banks of the stream. Other common mammals that likely use the area include gray squirrel, least shrew, and raccoon (Appendix I).

Southern leopard frog, bullfrog and eastern painted turtle were the only herpetofauna observed during the field reconnaissance. However, other herpetofauna that would likely use the bottomland hardwood community and beaver pond include black rat snake, northern water snake, gray treefrog, and eastern box turtle (Appendix I).

No visible signs of contamination were evident in the uplands at this site.

2.2.6 Site 11 - P Area Southeast Drainage Channel

Site 11 of Area P is located in the southeast corner of the Olin facility (Figure 5). The site is a narrow drainage (30cm wide) which receives runoff from portions of Area P. The drainage flows to the south and southeast, crosses under the road where it develops into an intermittent stream and eventually into a perennial stream that flows into Crab Orchard Lake. The total distance surface runoff from the site must travel before reaching Crab Orchard Lake is about 1 km (Figure 4).

Downstream from the site and across the road, the stream channel was approximately 1 m wide with sparse stream bank vegetation and limited algal growth. Bottom substrates consisted of sand and fine gravel over clay. Maximum depth in pools was 20 cm at the time of the site visit. Frogs and crayfish burrows were frequent along the stream. Other probable stream fauna include the larvae of aquatic midges (Chironomidae) and mosquitoes (Culicidae). No evidence of contamination or adverse ecological effects were noted in the drainages or stream.

The upland habitat at the site is essentially a lawn. A mixture of grasses are the primary cover type and the lawn appears to be mowed regularly. The drainage downstream and across the road from the site is a deciduous forest community dominated by oak, maple and hickory.

Avian species observed in the vicinity of the site included field sparrow, indigo bunting, american robin and northern mockingbird. Other common avian species that would likely use the site include brown-headed cowbird, common grackle and eastern bluebird (Appendix I).

During the field reconnaissance, white-tailed deer tracks were found in the drainage and fox squirrels were heard vocalizing in the adjacent woodlot. Other mammals that would likely use the site include eastern cottontail and eastern mole (Appendix I).

No herpetofauna were observed in the area, but species that would likely use the site include prairie kingsnake, eastern garter snake and eastern yellow-bellied racer. Species that would likely use the adjacent forest community include black rat snake, gray treefrog, and eastern box turtle (Appendix I).

No visible signs of contamination were evident in the uplands at this site.

2.2.7 Site 11A - P Area (North) Walkway Structures

Site 11A of Area P is located in the northern portion of Olin facility (Figures 5 and 6). The site is a series of drainages that carry runoff from the grounds off-site to the north. The two drainages that flow off-site, drain to the north into a deciduous forest and eventually into the same perennial stream that carries runoff from Sites 7, 20, 9 and 10. During the site reconnaissance, all drains and ditches were dry in the vicinity of the site. The total distance that surface runoff from the site must travel before reaching Crab Orchard Lake is less than 1.5 km (Figure 4).

The habitat at the site is essentially a lawn. A mixture of grasses are the primary cover type and the lawn appears to be mowed regularly. The drainage downstream and outside the Olin facility is a deciduous forest community dominated by white oak, southern red oak, sugar maple and shagbark hickory.

Avian species observed in the vicinity of the site during the field reconnaissance included indigo bunting, northern mockingbird, and house wren. Other common avian species that would likely use the site include american robin, field sparrow, brown-headed cowbird, common grackle and eastern bluebird (Appendix I).

No mammals were observed during the site reconnaissance, but species that would likely use the upland habitats within the Olin facility include white-tailed deer, eastern cottontail, eastern mole and deer mouse. Species that likely inhabit the adjacent forest community include white-tailed deer, eastern cottontail, deer mouse, fox squirrel and gray squirrel (Appendix I).

No herpetofauna were observed in the area, but species that would likely use the site include prairie kingsnake, eastern garter snake and eastern yellow-bellied racer. Species that would likely use the adjacent forest community include black rat snake, gray treefrog, and eastern box turtle (Appendix I).

No visible signs of contamination were evident in the uplands at this site.

2.2.8 Site 12 - Area 14 Impoundment

Area 14 is an active manufacturing area south of Crab Orchard Lake. Sherwin Williams stored and loaded munitions in the area until 1947 when Diagraph Corporation took over the buildings. Diagraph presently manufactures printing inks and stencils in the buildings between Site 12 and Site 14.

Site 12 is located within Area 14. The site is composed of a circular impoundment approximately 100 feet in diameter (Figure 7). In the past, this impoundment surrounded an above-ground storage tank. The banks of the impoundment are about 2 m above the surrounding terrain on the western and southern portions of the impoundment and generally less than 1 m above the surrounding terrain on the northern portion of the impoundment. There is a 2 m breach in the eastern end of the impoundment (Figure 7) that serves as the only above-ground source for off-site drainage.

The topography within the impoundment is such that most surface water drains toward the breach in the levee and out of the impoundment. Two low areas were found within the impoundment during the field reconnaissance. These areas were likely ephemeral ponds. However, during the field reconnaissance these areas contained saturated soils that were dominated by moist soil plants such as Carex sp. and Cyperus sp. During wet periods, these ephemeral ponds may support short-lived aquatic invertebrates typical of ephemeral habitats (larvae of chironomid midges and mosquitoes, small crustaceans), and may be utilized by frogs and dragonfly adults for feeding. No evidence of contamination or adverse ecological impacts were observed in these ephemeral ponds.

Upon leaving the site, surface runoff collects in a drainage that flows to the northwest through an old field where it joins with a perennial stream with wooded margins. This perennial stream, in turn, flows northward where it empties into Crab Orchard Lake. Overall, the total distance that surface runoff from the site must travel before reaching Crab Orchard Lake is about 3 km (Figure 8).

The site is currently overgrown with a diverse assemblage of trees, the oldest of which appear to be about 30 years old. Sycamore, black locust, honey locust, eastern red cedar, elms, ashes, oaks, and hickories dominate the overstory. Sassafras and persimmon, as well as younger trees of the overstory species mentioned above, dominate the midstory layer. The understory is well developed with an extensive covering of poison ivy, blackberry, brambles, Japanese honeysuckle and grasses.

Diagraph Corporation borders the site to the west and an old field community borders the site on the east. Dominant woody species associated with the old field are red cedar, pin oak, and autumn olive. Dominant herbaceous vegetation includes grasses, legumes and composites.

Avian species recorded during the field reconnaissance included yellow-breasted chat, house finch, northern cardinal, indigo bunting, blue jay, american goldfinch, and yellow-billed cuckoo. Other locally common species that should use the site during the breeding season include field sparrow, northern mockingbird, northern bobwhite, orchard oriole and northern oriole (Appendix I).

Mammals observed during the field reconnaissance included white-tailed deer and eastern cottontail. Other common mammals that would be expected to use the site include eastern mole, least shrew and deer mouse (Appendix I).

The only herpetofauna observed in the vicinity of the site during the field reconnaissance were eastern box turtles. Other herpetofauna that would likely use the site include prairie kingsnake, eastern garter snake, eastern yellow-bellied racer, American toad and five-lined skink (Appendix I).

No visible signs of contamination were evident in the uplands at this site.

2.2.9 Site 13 - Area 14 Change House

Site 13 of Area 14 is located southwest of the manufacturing and storage facility presently operated by Diagraph Corporation. The site is located approximately 500 m southwest of site 12. The site is now an open field dominated by grasses. The site formerly contained a building which was used for several different purposes prior to being demolished sometime between 1971 and 1980.

The topography of the site is relatively flat and gently sloping to the north and southeast. One low area was found at the southern end of the field. Due to periodic inundation and relatively impervious soils, this low area was less vegetated than the surrounding uplands area. Nonetheless, natural vegetation covered over 50% of the low area, which is likely an ephemeral pond. As discussed in the section on Site 12, during wet periods this area may support short-lived invertebrate taxa which typically inhabit temporary ponds. No evidence of contamination or adverse ecological effects were observed in wet areas near the site.

Surface runoff appears to eventually drain to the east, where it empties into the perennial stream discussed for site 12. Overall, the total distance that surface runoff from the site must travel before reaching Crab Orchard Lake is about 3.5 km.

The site is best characterized as an old field bordered by woodlots. Dominant woody vegetation in the old field includes young red cedar, sweet gum and ashes. Dominant herbaceous vegetation is comprised primarily of grasses, legumes and composites.

Avian species recorded in the vicinity of the site during the field reconnaissance included indigo bunting, red-tailed hawk and northern mockingbird. Other locally common avian species that should use the site during the breeding season include field sparrow, northern mockingbird, northern bobwhite, orchard oriole and northern oriole (Appendix I).

The site was heavily used by white-tailed deer as evidenced by numerous tracks and travel lanes located throughout the site. Several deer bedding areas also were found throughout the site and one deer was flushed from the site by the ecologists. Other common mammals that would likely use the vicinity include eastern cottontail, fox squirrel and deer mouse (Appendix I).

No herpetofauna were observed in the area, but species that would likely use the site include prairie kingsnake, eastern garter snake and eastern yellow-bellied racer. Species that would likely use the adjacent woodlots include black rat snake, gray treefrog, and eastern box turtle (Appendix I).

No visible signs of contamination were evident in the uplands at the site.

2.2.10 Site 14 - Area 14 Solvent Storage Drainage Ditch

Site 14 of Area 14 is in an active manufacturing and storage facility operated by Diagraph Corporation. The site is a drainage network which receives runoff from adjacent manufacturing and warehouse facilities, including areas where liquid chemicals are stored in drums and in above-ground storage tanks (Figure 9). The tanks presently contain xylene, diethylene glycol and diacetone alcohol. The drains are narrow (30-50 cm wide) and flow into a small intermittent stream west of the row of buildings.

Surface runoff appears to drain to the north, where it crosses under the east-west paved road and eventually empties into the perennial stream discussed in the section on Site 12. Overall, the total distance that surface runoff from the site must travel before reaching Crab Orchard Lake is about 3.5 km (Figure 8).

One of the drainage ditches located at the southwestern corner of the site contained black anoxic sediments. Upon disturbing the sediments within this drain, a sheen was observed on the water surface. A slight solvent/hydrocarbon odor of the sediments was also noted. Other drains near the site contained predominantly clay substrates and did not appear contaminated. All drainage channels on the northwest side of the road were lined with dense vegetation, and abundant algal growth. Aquatic fauna observed in drains included water striders (Gerridae), adult dragonflies (Anisoptera), chironomid midge larvae, oligochaete worms, frogs, and two small fishes (likely Centrarchidae). The observed contamination appeared to be localized and was not associated with any apparent ecological impacts on aquatic biota or vegetation.

The upland habitat associated with the site consists of mowed grass east of the gravel road and adjacent to the Diagraph buildings and well-vegetated drainages and old fields west of the gravel road. Dominant plant species along the drainage west of the gravel road include black cherry, sycamore, ashes, mulberry, willows, elms and black gum. Herbaceous wetland plants growing in this drainage included various sedges, cattails, grasses and beggar's lice. Woody plants associated with the nearby old fields west of the gravel road included pin oak, sycamore, red cedar and ashes. Herbaceous vegetation included poison ivy, blackberry, grasses, legumes and composites.

Avian species recorded in the vicinity of the site included field sparrow, blue jay, indigo bunting, yellowthroat and northern bobwhite. Other locally common avian species that likely use the site during the breeding season include american robin, northern mockingbird, yellow-breasted chat, orchard oriole and northern oriole (Appendix I).

White-tailed deer tracks were observed adjacent to the drainage and Diagraph personnel reported regularly seeing numerous deer in the vicinity (M. Maeser pers. commun.). Other common mammals that would likely use the vicinity include eastern cottontail, fox squirrel, deer mouse and least shrew (Appendix I).

Southern leopard frogs were the only herpetofauna recorded during the field reconnaissance. However, species that would likely use the site include prairie kingsnake, eastern garter snake, eastern yellow-bellied racer, black rat snake, bullfrog, gray treefrog, and eastern box turtle (Appendix I).

No visible signs of contamination were evident in the uplands at the site.

2.2.11 Site 16 - Area 7 Industrial Park

Area 7 is an industrial park which originally contained 36 large buildings arranged in six rows; each row is served by a railroad siding. A drainage way bisects the park and receives runoff from the entire industrial park. It discharges to Crab Orchard Lake approximately 600 m to the north. In the mid-1980s, black residues were observed near three buildings formerly used to recover and recycle waste oil and around two buildings occupied by a company which refurbished mining equipment (O'Brien and Gere 1988).

Site 16 of Area 7 is an industrial park which originally contained 36 large buildings arranged in six rows; each row was served by a railroad spur which are no longer present. Several buildings in the park still house active industrial operations.

A south to north drainage bisects the park and receives runoff from the entire industrial park (Figure 10). The drainage on the site is an intermittent stream, with several semi-permanent pools surrounded by dense vegetation. The drainage flows to the north and changes into a perennial stream within 200 m of the site. This perennial stream originates about 400 m from the site and is bordered by hardwoods and eventually discharges into Crab Orchard Lake. The total distance that runoff from the site must travel before reaching Crab Orchard Lake is less than 1 km (Figure 8). There was no evidence of stream flooding.

Low lying areas around Building 3-4 also contained stagnant water and were populated by mosquito larvae (Culicidae) and water striders (Gerridae). The intermittent stream was approximately 1 m wide and up to 30 cm deep, with a clay bottom. Streambank vegetation was abundant around pools. Stream fauna observed at the site included crayfish, frogs, dragonfly nymphs (Anisoptera), aquatic snails (Pulmonata), oligochaete worms, and isopods. The stream widened in the forested area downstream of the industrial park. Aquatic fauna observed in this section included juvenile fish, frogs, water striders and crayfish. Additional likely invertebrate fauna includes chironomid midge and mosquito larvae. No visual evidence of contamination or adverse ecological effects were found in these surface waters.

Within the industrial park, the upland habitats consist primarily of grasses, legumes and composites. These uplands appear to be mowed 2-3 times per year, and provide limited wildlife habitat. The margins of two pools on the drainage are heavily vegetated with willows and grasses.

Avian species recorded in the vicinity of the site included killdeer, indigo bunting, northern mockingbird, and eastern meadowlark. Other locally common avian species that likely use the site during the breeding season include rock dove, mourning dove, northern bobwhite, american robin, orchard oriole and northern oriole (Appendix I).

White-tailed deer tracks and droppings and eastern cottontail droppings were found throughout the site during the field reconnaissance. Other common mammals that likely use the site include eastern mole and deer mouse (Appendix I).

Southern leopard frogs were observed in and adjacent to the wet areas on the site. No other herpetofauna were observed in the area, but species that would likely use the area include bullfrog, prairie kingsnake, eastern garter snake and eastern yellow-bellied racer (Appendix I).

A wet area east of the drainage where sample 16-3 was taken contained water with an oily sheen. Vegetation in the wet area appeared normal and there were no other visible signs of impacts.

2.2.12 Site 18 - Area 13 Loading Platform

Area 13 consists of approximately 85 bunkers originally built to store 500 pound bombs. Site 18 is within Area 13 and consists of a concrete loading platform where the bombs were loaded onto railroad cars. The railroad spurs were removed at an indeterminate date.

The topography around the site is relatively flat. The complex of bunkers is drained by several ditches. Runoff from the vicinity appears to travel to the west-northwest into a perennial stream. The perennial stream meanders through a deciduous forest and eventually joins with a larger stream that flows into Crab Orchard Lake. The total distance that runoff from the site must travel before reaching Crab Orchard Lake appears to be over 3 km.

The ditches in the area typically had a hard clay bottom covered with plant detritus. Aquatic organisms observed in the stagnant water approximately 20 cm deep of one ditch in the vicinity included frogs, tadpoles, fingernail clams (Sphaeridae), isopods, chironomid larvae, water boatmen (Corixidae), and aquatic beetles (Dytiscidae). No visual evidence of flooding, contamination, or adverse ecological effects were noted in the ditches examined.

The uplands in the area are reverting from old field habitats to those overgrown with deciduous trees. The old railroad bed is covered with trees and herbaceous plants. Dominant trees in the area include white oak, pin oak, southern red oak, slippery elm, box elder, mulberry, sassafras, persimmon and red cedar. Grasses and legumes are the dominant herbaceous cover.

Avian species recorded in the vicinity of the site included indigo bunting, northern mockingbird, northern bobwhite, field sparrow and dickcissel. Other locally common avian species that likely use the site during the breeding season include yellow-breasted chat, mourning dove, american robin, orchard oriole and northern oriole (Appendix I).

White-tailed deer tracks and droppings were found throughout the area during the field reconnaissance. Other common mammals that likely use the site include eastern cottontail, fox squirrel and deer mouse (Appendix I).

Southern leopard frogs (adults and tadpoles) were observed in wet areas adjacent to the site. No other herpetofauna were observed in the area, but species that would likely use the area include bullfrog, American toad, eastern box turtle, prairie kingsnake, eastern garter snake, black rat snake and eastern yellow-bellied racer (Appendix I).

No visible signs of contamination were noted in the uplands at the site.

2.2.13 Site 20 - D Area South Drainage Channel

Site 20 in Area D, is part of Olin's active manufacturing facility. Site 20 consists of a drainage which receives runoff from a nearby abandoned building that reportedly used to dump chemicals. Several chemical drums are still present on the northeast side of the building (Figure 11).

The site slopes to the east. Runoff from the vicinity appears to collect in a drainage that flows northeast, through a culvert, then flows southeast until it joins with the same perennial stream that carries runoff from Sites 7, 9, 10, and 11A. This perennial stream originates about 1000 m from the site and meanders through a bottomland hardwood community and eventually flows into Crab Orchard Lake. The total distance that runoff from the site must travel before reaching Crab Orchard Lake appears to be about 2 km (Figure 4).

The upper reaches of the drainage are well-vegetated and dry. During the field reconnaissance, the closest pool of water to the abandoned building was found in the drainage east of the culvert that passes under the gravel road. This pool was a relatively small (1 m diameter) pond which contained crayfish burrows. Frogs were also observed in the general area. No indication of contamination or adverse ecological effects were noted in the drainage.

Within the Olin facility, the upland habitats consist primarily of grasses, legumes and composites. These uplands appear to be periodically mowed, and provide limited wildlife habitat. However, inside the Olin facility, the last 50 m of the drainage is wooded. Dominant woody species in this section of the drainage include black cherry, dogwood, willow, and mulberry. Additionally, an old rubble pile (containing concrete blocks, cinder blocks, bricks, etc.), is situated a few meters north of the drainage. This area contains large oaks, willows and cottonwoods. Several large pin oaks are also scattered throughout the uplands between the eastern side of the building and the Olin facility perimeter. Outside and downstream of the Olin facility, the perennial stream flows through a deciduous forest that is described in detail in section 2.2.4.

Avian species observed within the site included red-tailed hawk, eastern bluebird, field sparrow, and house wren. Other locally common species that should use the site during the breeding season include dickcissel, eastern meadowlark, northern bobwhite, blue jay, northern mockingbird, and american robin (Appendix I).

White-tailed deer tracks were noted in the site during the field reconnaissance. Other common mammals that would likely use the site include eastern cottontail, eastern mole, and deer mouse (Appendix I).

Southern leopard frogs were observed in the pool downstream of the culvert. Other herpetofaunal species that would likely use the habitats within the Olin facility include American toad, prairie kingsnake, eastern garter snake and eastern yellow-bellied racer (Appendix I).

There were no visible signs of contamination in the uplands at the site.

2.2.14 Site 21- Area 7 Southeast Corner Field

Site 21 is within a fenced pasture area located near the southeast corner of the refuge. A pile of concrete rubble present near the northwest corner of the site appears to be the remains of a building foundation.

The site is high and drains to the east and southeast. Drainage from the site flows into an intermittent stream that drains to the northeast. At the time of the field reconnaissance, the stream was heavily trampled by cattle and did not support any appreciable aquatic life. The stream's fauna is most likely limited to short-lived invertebrates typical of ephemeral habitats. No evidence of contamination was observed in the stream.

The upland habitat on the site is best characterized as being over 50% covered in an overstory of large trees, namely black locust, honey locust, hickory, silver maple and sugarberry. Due to the presence of cattle, there is virtually no woody understory and grasses are the predominant groundcover. The site was examined by representatives of the U.S. EPA, IEPA, FWS, USACE, and Golder on October 27, 1992, at which time no specific targets for analytical sampling were observed. The site was consequently listed as needing no further investigative action. The site ecological reconnaissance conducted on July 23, 1993 re-affirmed this conclusion.

2.2.15 Site 22A - Old Refuge Shop Post Treating Facility

Site 22A is the location of the old refuge shop. The site is behind and adjacent to a complex of buildings that includes the previous Crab Orchard NWR headquarters (Figure 12). At this location, pine posts were treated with diesel fuel which contained pentachlorophenol (O'Brien and Gere 1988).

The site is a rectangular open field, bordered on the north, west, and south sides by woodlots. The site is bordered on the east by the NWR buildings mentioned above. The area where the soil samples were collected is relatively flat, with a gradual slope to the north. However, north from the sampling area, the slope increases. Runoff from the site travels to the north, empties into an intermittent stream in a deciduous woodlot, travels west and empties into Pigeon Creek, north of the Pigeon Creek moist soil waterfowl impoundments. The total distance that runoff from the site must travel before reaching Crab Orchard Lake appears to be just over 1 km (Figure 4).

Pigeon Creek Moist Soil Unit consists of one 14 acre compartment, with an average depth of 30 cm (J. Maybery, U.S. FWS, pers. comm.). The impoundment is located approximately 1 km from the site. Runoff from the site does not appear to empty directly into the impoundment. However, during periods of heavy rain, Pigeon Creek tends to flow over the banks of the impoundment and into the moist soil unit. There is a water-level control structure at the southwest corner of the unit, which feeds into Pigeon Creek approximately 300 yards from Crab Orchard Lake.

The intermittent stream channel was 50-80 cm wide at the time of the site visit with a maximum depth of 10 cm. No flow was present. Bottom substrates were predominantly soft clay with moderate filamentous algal growth (Cladophora). Visible stream fauna included southern leopard frogs, and aquatic beetles (Dytiscidae). In addition, chironomid midge and mosquito larvae probably occur in the stream. No evidence of contamination or adverse ecological impacts were observed in the stream.

The upland habitat associated with the site is an open field dominated by grasses such as foxtail and legumes such as yellow sweet clover. The vegetation appeared not to have been mowed in several years. The woodlot bordering the north side of site is a mixed age hardwood stand containing several openings. Dominant tree species include white oaks, shagbark and bitternut hickories, red maple, sassafras, elms, and ashes. Dominant groundcover species include nettles, poison ivy, and various grasses.

No birds were observed in the field during the site reconnaissance. However, indigo bunting, northern cardinal, house wren, rufuos-sided towhee, american robin, american goldfinch, common crow and field sparrow were recorded in the woodlot north of the site. Other locally common species that should use the vicinity during the breeding season include dickcissel, northern mockingbird, morning dove, yellow-billed cuckoo and blue jay (Appendix I).

White-tailed deer tracks and droppings and eastern cottontail droppings were found throughout the site during the field reconnaissance. Other common mammals that likely frequent the vicinity include fox squirrel and deer mouse (Appendix I).

No herpetofauna were observed in the area, but species that would likely use the open field include prairie kingsnake, eastern garter snake and eastern yellow-bellied racer. Species that would likely use the adjacent forest community include black rat snake, gray treefrog, and eastern box turtle (Appendix I).

A few small (<30 cm) unvegetated areas were noted at the site during the field reconnaissance. These areas were not associated with gravel deposits and the reason that these areas were unvegetated was uncertain.

2.2.16 Site 27 - Crab Orchard Creek Dredge Area

The floodplain areas of Site 27 were examined October 28, 1992, by representatives of the U.S. EPA, IEPA, FWS, USACE, and Golder, at which time no sampling targets were apparent. It was decided that no investigation activities were warranted during Phase I. Another inspection of Site 27 was made by two Golder Associates ecologists on July 23, 1993. Once again, no sampling targets were apparent.

2.2.17 Site 35 - Area 9 East Waterway

Site 35 is a low-lying area in an agricultural field east of Area 9. O'Brien and Gere (1988) reported that the lack of vegetation in the depression indicated the presence of potential contaminants. The site area was visited by representatives of the U.S. EPA, IEPA, FWS, USACE, and Golder on October 28, 1992. The reported depression could not be found and signs of potential contamination or potential contamination sources were not observed. Because of the lack of specific targets, no investigations of Site 35 were warranted for Phase I.

Site 35 was visited on July 23, 1993 during the ecological field reconnaissance. The ecologists found a low-lying area in a hayfield at about the same location as described by O'Brien and Gere (1988). The soil was saturated and contained water-tolerant grasses such as barnyardgrass and sedges. The area was completely vegetated, so it is uncertain whether this was the same area described by O'Brien and Gere as being bare. However, a plausible explanation is that when O'Brien and Gere visited the site, it was bare due to previous inundation and drying rather than being bare due to contamination.

2.2.18 Waste-Water Treatment Plant (Site 36)

The waste-water treatment facility was built in the mid-1940s and since then has processed waste water from industrial and NWR facilities within the eastern portions of the Refuge. The original equipment is still in use and includes three aeration tanks, an anaerobic digestion tank, sand beds, clarification tanks and a chlorination system. Two small ponds, located east of the sand beds, were dug in the late 1950s. Two lagoons were added south of the aeration tanks in 1970-1971. These structures are shown in Figure 13.

According to site personnel interviewed on October 29, 1992, finished water from the treatment facility is chlorinated and discharged to the north. This discharge water empties into Dove Creek, an intermittent stream that in turn flows to the southeast where it empties into Pigeon Creek. Pigeon Creek originates about 9 km north of the site and flows to the south and empties into Crab Orchard Lake. The total distance that the discharged water must travel to reach Crab Orchard Lake is approximately 1.5 km (Figure 4).

Water removed from sludge on the sand beds probably drains to the adjacent ponds. The pond furthest east is used as an overflow. During periods of heavy rainfall surface runoff from the sand beds and ponds would travel to the east and empty into Dove Creek. The total distance that runoff from this area must travel to reach Crab Orchard Lake is less than 1.5 km.

The large lagoons were built as a backup system due to problems with the aeration system in the late 1960s and are reportedly used on an occasional basis. Water passes from the primary to the secondary lagoon and is chlorinated before discharging into the drainage way to the east (i.e., Quail Creek). Quail Creek is intermittent, and during periods of flow it drains into Pigeon Creek. The total distance that runoff from this area must travel to reach Crab Orchard Lake is approximately 1 km.

At the time of the site reconnaissance, both lagoons were highly enriched, as indicated by green, turbid water. Visible fauna included dragonfly adults (Anisoptera), water striders (Gerridae), southern leopard frogs and bullfrogs, as well as turtles in the primary lagoon and fish or turtles in the secondary lagoon. Large numbers of cladoceran zooplankton have been observed to populate the lagoons in the recent past. The smaller artificial pond near the sand beds contained large mats of algae, leopard frogs and bull frogs, aquatic beetles (Dytiscidae), and water striders (Gerridae). Numerous adult dragonflies (Anisoptera) and damselflies (Zygoptera) were also seen. In addition, oligochaete worms and larvae of chironomid midges and mosquitoes likely inhabit the pond. The larger pond was completely covered with duckweed (Lemna) and was surrounded by very dense vegetation. Dove creek was 50-100 cm wide and approximately 10 cm deep with a low flow rate and sand/clay bottom substrates. The water at its origin (waste water treatment plant discharge pipe) was clear. No aquatic organisms were observed in the upper reaches of the creek, presumably as a result of the chlorination of the effluent. No evidence of contamination other than moderate to severe organic enrichment was observed in any waterbodies at the site.

All drainages from the waste-water treatment facility flow into the bottomland hardwood community north and east of the site. Dominant trees in this community consist of cottonwoods, red maple, swamp chestnut oak and sycamore. Dominant groundcover species include poison ivy, nettles, day flowers, and numerous grasses.

The avian species observed in the bottomland hardwood community during the field reconnaissance included indigo bunting, yellow-billed cuckoo, blue jay, and downy woodpecker. Other common woodland species that likely use the area during the breeding season include eastern wood-peewee, eastern phoebe, red-headed woodpecker, prothonotary warbler, louisiana waterthrush, northern parula, red-eyed vireo and wood thrush (Appendix I).

White-tailed deer and raccoon tracks were abundant along the perennial stream during the field reconnaissance. Other common mammals that likely use the area include fox squirrel, gray squirrel, and least shrew (Appendix I).

Southern leopard frogs, bullfrogs and eastern painted turtles were noted in the lagoons and ponds during the field reconnaissance. No herpetofauna were observed in the bottomland hardwood community during the walkover, but locally common species that likely use the area include black rat snake, southern leopard frog, gray treefrog, and eastern box turtle (Appendix I).

2.3 Constituent Assessment and Potential Migration Pathways

The constituents considered for this investigation of ecological risk were those which were analyzed from soil, sediment and sludge samples collected from each of the sites under investigation and include volatile organic compounds, semivolatile organic compounds, organochlorine pesticides, polychlorinated biphenols (PCBs), explosives, dioxins/furans and inorganic compounds (largely metals) (Tables 3-8). These data are given in the Draft Phase I RI report (Golder Associates 1993).

All data collected from the study sites were screened initially by comparing measured concentrations to a set of criteria developed specifically for this study. These Preliminary Levels of Concern (PLC) are based on the minimum values from the following published criteria:

- IEPA (1991): Leaking Underground Storage Tank Manual;
- NOAA (1991): Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.

- CCME (1991): Interim Canadian Environmental Quality Criteria for Contaminated Sites;
- Ontario Environment (1992): Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario.

In cases where the minimum value was lower than background levels or where there were no published criteria, the PLC was set to equal the upper 95 % confidence interval value computed from background soil samples. The PLCs are given in Tables 9 and 10.

Constituents measured at values exceeding the PLCs are summarized in Table 11. The following subsections list the constituents from each site selected for further evaluation and discusses source, nature and extent of contamination and potential fate and transport pathways for the constituents of concern at each site.

2.3.1 Site 7

Levels of all constituents were below PLCs.

2.3.2 Site 7A

Manganese was measured in one of the four samples at a concentrations of 1200 mg/kg, slightly above the PLC of 1080 mg/kg. However, that value for manganese was biased positively due to analytical problems. Since no other metals were detected at levels above the PLC, it was assumed that this manganese value was a laboratory artifact and no further evaluation for manganese was completed for this site. All other constituents were below PLCs.

2.3.3 Site 8

Methyl ethyl ketone (MEK) was detected in one sample (0.06 mg/kg) at levels above the PLCs (>MDL). Levels of all other constituents were below PLCs.

Methyl ethyl ketone is soluble, volatile and does not appreciably sorb to organic sediments or accumulate in plant and animal tissue (Table 12). Decay rates for MEK are moderately fast to fast (Table 13).

The primary transport mechanisms for MEK would be via air (vapors) or water (groundwater or stream). Off-site transport via dust emissions would be negligible, given the vegetation cover at this site coupled with the chemical characteristics of MEK.

2.3.4 Site 9

Silver was detected at a concentration of 1.7 mg/kg in the one sediment sample analyzed from this site, which is above the PLC of 0.77 mg/kg. Levels of all other constituents were below PLCs.

Fate and transport processes governing silver are difficult to specify with certainly since the forms of silver that would be present are highly dependant upon site-specific factors such as pH, presence of salts, organics, etc. It is probable, however, that the bulk of silver present at this site is associated with particulate matter rather than in a soluble form, since silver hydrolizes and becomes insoluble at pH above 7.5 (Boyle 1968). For this analysis, it was conservatively assumed that silver partitioned equally between dissolved and particulate phases and that silver would accumulate in both plant and animal tissue (Table 14).

If silver is predominantly in a particulate form, then the primary transport mechanism from this site would be via resuspension of bottom sediments and transport via the stream. The dense vegetation noted at this site would limit the potential effects of fugitive dust emissions associated with periodic bank flooding.

2.3.5 Site 10

A number of volatile and semi-volatile organics and two metals were detected at concentrations exceeding the PLCs in one or both of the sediment samples collected from this site:

Compound	Maximum Sample Concentration (mg/kg)	Preliminary Level of Concern (mg/kg)
Methyl ethyl ketone	0.020	>MDL
Benzo(a)anthracene	0.25	0.0026
Benzo(b)fluoranthene	0.34	0.0036

Compound	Maximum Sample Concentration (mg/kg)	Preliminary Level of Concern (mg/kg)
Fluoranthene	0.69	0.6
Phenanthrene	0.45	0.1
Pyrene	0.51	0.1
Cadmium	0.76	0.75
Silver	1.24	0.77

The source of this apparent contamination is not known (Golder Associates 1993).

Fate processes for MEK are described in Section 2.3.3. The PAHs are poorly soluble in water, have low vapor pressures, and readily sorb to organic sediments and bioconcentrate in animal tissues (Table 12). Decay rates for the PAHS tend to be low (Table 13). As discussed above for Site 9, processes governing metals at these sites cannot be stated with certainty. Even so, it is probable given the alkaline conditions and presence of organic matter that most of the silver and cadmium at this site would be bound to particulate matter. For computation of exposure concentrations (Section 3.3), it was conservatively assumed that both metals partitioned equally between dissolved and particulate phases and that they would accumulate in plant and animal tissue (Table 14).

Since the samples from this site were collected from sediments near a perennial stream, these contaminants may potentially be transported in surface water and groundwater off site to Crab Orchard Lake. Off-site transport of these compounds would likely be greatest during heavy rainfall, when high stream flows might enhance bedload transport and facilitate resuspension of contaminated bottom sediments. Given the characteristics of the site and these compounds, transport via dust emissions would be negligible and transport via air vapors restricted to MEK.

2.3.6 Site 11

Arsenic and silver was detected in one soil sample analyzed at concentrations of 15 and 1.6 mg/kg, respectively, slightly above the PLCs of 11.8 and 0.77 mg/kg, respectively. All other constituents were below PLCs or background levels.

Fate processes affecting silver are described in Section 2.3.4. Unlike silver, arsenic occurs primarily in a soluble form in surface water (Eisler 1988). For computation of exposure concentrations (Section 3.3), it was, therefore, assumed that dissolved forms of arsenic would account for 10 % of the total arsenic concentration in surface waters (Table 14).

Since the samples from this site was collected from sediments at the bottom of a drainage channel, silver and arsenic may potentially be transported off site via surface water following heavy rainfalls. Given the characteristics of the site and these compounds, transport via air vapor and dust emissions would be negligible.

2.3.7 Site 11A

Two volatile organics, acetone (0.52 mg/kg) and MEK (0.014 mg/kg), plus one explosive, 2,4,6-trinitrotoluene (2,4,6-TNT; 0.38 mg/kg) were detected in one of five soil samples at concentrations exceeding the PLCs (0.37, >MDL, >MDL, respectively). In addition, silver levels exceeded the PLC of 0.77 mg/kg in all five samples (0.86-1.8 mg/kg). Levels of all other constituents were below PLCs.

Information on the fate of the volatile organics and silver is given in the preceding sections (acetone behaves similarly to MEK). 2,4,6-TNT is highly soluble in water, has a relatively low affinity for organic sediments, is not volatile, and does not appreciably bioconcentrate in animal or plant tissue (Table 12). Decay rates in aerobic surface waters are extremely rapid, with half lives ranging from 0.16-1.28 hours (due to photolysis); half lives in soils and groundwater range from 1-6 months (Table 13; Howard et al. 1991).

Given the high solubility and lack of partitioning to sediments, the primary transport mechanism for acetone, MEK, and 2,4,6-TNT would be via water, either surface or groundwater runoff from the site. Since the area is predominantly grassed, fugitive dust emissions are likely negligible. The low vapor pressure indicates that volatilization would not be an important fate for 2,4,6-TNT, but is a potential fate for acetone and MEK. Since most silver is likely in a particulate form, the primary transport mechanism for this metal would be via erosion and surface runoff following heavy rainfalls.

2.3.8 Site 12

Two volatile organics, acetone (1.7 mg/kg) and MEK (0.007 mg/kg) were detected in one of two soil samples at concentrations exceeding the PLCs (0.37 mg/kg and >MDL, respectively). In addition, concentrations of two PAHs, phenanthrene (0.32 mg/kg) and pyrene (0.42 mg/kg) and one metal, silver (1.1-1.3 mg/kg), exceeded their PLCs in one or both samples (PLCs: 0.1, 0.1, 0.77 mg/kg, respectively). Levels of all other constituents were below PLCs.

Fate processes for these compounds are discussed in previous sections. The primary transport mechanisms at this site include surface runoff following heavy rainfalls, groundwater (all compounds) and air vapors (acetone and MEK). Since the area is heavily forested, fugitive dust emissions are likely negligible.

2.3.9 Site 13

No samples were collected from this site and no further RI investigation are planned.

2.3.10 Site 14

A number of volatile and semi-volatile organics and metals were detected at concentrations exceeding the PLCs in one or both of the soil samples analyzed from this site:

Compound	Maximum Sample Concentration (mg/kg)	Preliminary Level of Concern (mg/kg)
Ethylbenzene	11.3	0.1
Methylene chloride	0.21	0.065
Methyl ethyl ketone	0.007	>MDL
o-Xylene	4.6	0.1
m,p-Xylene	28	0.1
Cadmium	0.94	0.75

Compound	Maximum Sample Concentration (mg/kg)	Preliminary Level of Concern (mg/kg)
Chromium	60	57.4
Copper	23	20.9
Cyanide	4.3	0.1
Lead	150	31
Manganese	1800	1080
Mercury	0.26	0.15
Silver	2.4	0.77

All other constituents were below PLCs or background levels.

The primary fate processes for MEK, cadmium and silver are described in previous sections. Ethylbenzene, methylene chloride and xylenes are soluble in water, have a moderate affinity for organic sediments, are volatile, and do not appreciably bioconcentrate in animal or plant tissue (Table 12). Decay rates are rapid in air and moderately fast in aerobic surface waters (Table 13). The other compounds are diverse with respect to fate processes. For example, cyanide, a complex group of inorganic and organic compounds may be present in many different forms, e.g., free cyanide, mettocyanide complexes and synthetic organocyanides. However, only free cyanide is of environmental concern because of its high toxicity. The amount of free cyanide at this site depends upon numerous factors such as the presence of other metals and salts and pH. For this assessment, we have conservatively assumed that all dissolved cyanide is present as free cyanide and that most (90 %) of the cyanide present in water would be in the dissolved form (Table 14).

Like cyanide, the exact forms of the metals present at this site are difficult to state with certainty. It is probable, however, that the bulk of the metals identified here are associated with particulate matter rather than in a soluble form, since pH is expected to exceed 7 and all of these metals are most soluble under acidic conditions (CCRM 1987). For calculation of exposure concentrations, it was conservatively assumed that these metals partitioned equally between dissolved and particulate phases and that they could accumulate in both plant and animal tissue (Table 14).

Since the samples were collected from soils in a drainage ditch these contaminants may potentially enter surface water (or groundwater) and be transported downstream to Crab Orchard Lake. The high vapor pressure (and odors noted at the site), also indicates that volatilization and air transport are potentially important fates for the volatile organic compounds. The dense vegetation at this site would limit transport via fugitive emissions.

2.3.11 Site 16

Aroclor-1254 (103 mg/kg), aroclor-1260 (61 mg/kg), cadmium (0.9 mg/kg), copper (35 mg/kg) and silver (1.18 mg/kg) were all detected in one or both samples at levels exceeding their PLCs (0.05, 0.005, 0.75, 20.9, 0.77 mg/kg, respectively). Levels of all other constituents were below PLCs.

Fate processes for all of these constituents of concern, except for PCBs, are described in previous sections. PCBs are slightly soluble in water, moderately volatile, readily sorb to organic carbon and bioaccumulate in animal tissue (Table 12). Individual PCBs vary widely in their susceptibility to biodegradation; in general, decay rates decline with increasing numbers of chlorine atoms per molecule (Verschueren 1983).

Since the samples were collected from near a drainage ditch, these contaminants may potentially enter surface water (or groundwater) and be transported downstream to Crab Orchard Lake. The vegetation present at this site would limit transport via dust emissions.

2.3.12 Site 18

No samples were collected from this site.

2.3.13 Site 20

Lead (50 mg/kg) and silver (1.5 mg/kg) were the only two constituents measured at levels above the PLCs (31 and 0.77 mg/kg, respectively).

Fates for these constituents are discussed in previous sections.

Since the samples were collected from soils near a drainage ditch, these contaminants may potentially enter surface water (or groundwater) and be transported downstream to Crab Orchard Lake. Vegetation present at this site would limit transport via dust emissions.

2.3.14 Site 21

No samples were collected from this site.

2.3.15 Site 22A

A number of different volatile organics, PAHs, pentachlorophenol (PCP), pesticides and derivatives, dioxins/furans, and metals were detected at concentrations above the PLCs in soil samples collected from this site (Table 15).

The primary fate pathways for the volatile organics, PAHs and metals have been described in previous sections. Pentachlorophenol is soluble in water, not volatile, and readily sorbs to organic carbon and bioaccumulates in animal tissue (Table 12).

Decay rates for PCP are moderately fast in surface water but slow in soils and groundwater (Table 13). The pesticide DDT and its derivatives DDD and DDE are similar to PCP in that they are water soluble, non-volatile, readily sorb to organic carbon, bioaccumulate in animal tissue and generally decay at slow rates (Tables 12, 13). Dioxins and furans are not water soluble nor volatile, readily sorb to organic carbon, bioaccumulate in animal tissue, and decay at slow rates (Tables 12, 13).

At this site, all soil samples were collected from grassy, open areas. Thus, the primary transport mechanisms for these compounds include air vapors for the volatile organics, surface runoff of contaminated soil particles following heavy rainfalls, groundwater, and possibly fugitive dust emissions, particularly during periods when the grass cover is disturbed or reduced.

2.3.16 Site 27

No samples were collected from this site.

2.3.17 Site 35

No samples were collected from this site.

2.3.18 Site 36

Dove Creek

Aldrin, PCBs, and several metals were detected at concentrations above the PLC in sediment samples collected from Dove Creek:

Compound	Maximum Sample Concentration (mg/kg)	Preliminary Level of Concern (mg/kg)
Aldrin	0.77	0.002
Aroclor-1248	8.9	0.03
Aroclor-1254	8.2	0.05
Aroclor-1260	0.95	0.005
Cadmium	24	0.75
Copper	37	20.9
Lead	61	31
Mercury	0.26	0.15
Silver	1.7	0.77
Zinc	158	120

Levels of all other constituents were below PLCs:

The primary fates for all of these constituents except aldrin have been described in previous sections. Aldrin is an organochlorine pesticide that has a high affinity with organic carbon, is not readily soluble in water, has a low vapor pressure, and bioaccumulates in animal tissue (Table 12). Decay rates for aldrin tend to be low in both water and soils with half lives due to aerobic biodegradation ranging from 3 weeks to 1.6 years; half lives in air are rapid due to photo-oxidation and range for 1-10 hours (Table 10; Howard et al. 1991).

The primary transport mechanism for these compounds at this site is via water, either surface or groundwater transport. Since these samples were collected in a creek bed, off-site transport by fugitive dust emissions and volatilization are likely negligible.

West Pond

Cadmium (6.0 mg/kg) and silver (1.7 mg/kg) were detected in samples collected from the bottom of the west pond at levels exceeding their PLCs (0.75 and 0.77 mg/kg, respectively). Levels of all other constituents were below PLCs.

The primary fates for these constituents have been described in previous sections.

Since these samples were collected from bottom sediments where surface water was present, transport by fugitive dust emissions or volatilization would not be significant. Thus, the primary transport mechanisms will be associated with either groundwater seepage from the site or surface runoff, particularly following heavy rainfalls when the lagoons may overflow.

East Pond

A number of organic compounds were detected at concentrations greater than the PLCs in two sludge samples collected from the east pond: 12 PAHs (naphthalene, 2-methylnaphthalene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(a)pyrene,) plus aldrin, bis(2-ethylhexyl)phthalate, dibenzofuran and PCBs (Table 16). In addition, antimony, cadmium, chromium, copper, lead, manganese, mercury, nickel, silver and zinc levels exceeded PLCs.

The primary fate and transport pathways for most constituents have been discussed in previous sections; the remaining ones are discussed below. Bis(2-ethylhexyl)phthalate, napthalene and 2-methylnaphthalene are relatively soluble in water, non to slightly volatile, sorb readily to organic carbon and bioconcentrate in animal tissue (Table 12). Decay rates are highly variable for these organic compounds. For the low molecular weight compounds, half-lives are in the order of several days to several months in soil and surface water and range from several months to a few years for groundwater (Table 13). In contrast, the high molecular weight PAHs tend to decay very rapidly in surface waters due to photolysis but very slowly in soils and groundwater. Decay rates for bis(2-ethylhexyl)phthalate and dibenzofuran are moderate in surface waters and soils (biodegradation half-lives 5-28 days) and slightly lower in groundwater (Howard et al. 1991).

The fate and transport processes governing the metals of concern are difficult to specify with certainty since the forms of metals that might be present are highly dependent upon site-specific information such as pH, redox, temperature, presence of other metals and salts, hardness, substrate composition, etc. Much of this information is not available from the study site, so the following discussion of these metals is general in nature. Of the metals identified here, antimony is the most soluble and, thus, most likely transported in solution, i.e., surface runoff or groundwater (U.S. EPA 1979). In natural surface water, up to 50 % of antimony might be soluble (Baudo et al. 1990). In contrast, the other metals tend to be poorly soluble in water (U.S. EPA 1979), and the dissolved fraction probably represents only a small percentage (<10%) of the total (Baudo et al. 1990). For this assessment it was conservatively assumed that 50 % of these metals would be soluble in water (Table 14). Bioconcentration in the aquatic environment is possible for all of these metals (Table 13).

Since all samples were collected from bottom sediments where surface water was present, transport by fugitive dust emissions or volatilization would not be significant. Thus, the primary transport mechanisms will be associated with either groundwater seepage from the site or surface runoff, particularly following heavy rainfalls when the lagoons overflow.

Primary Lagoon

Acetone (0.68 mg/kg) and the PCB's aroclor-1248 (0.059-0.15 mg/kg) and aroclor-1254 (0.059-0.18) were detected in both sludge samples at concentration above the PLCs of 0.37, 0.03, and 0.05 mg/kg, respectively.

Fate and transport processes for these constituents are discussed above.

Since all samples were collected from bottom sediments where surface water was present, transport by fugitive dust emissions or volatilization would not be significant. Thus, the primary transport mechanisms will be associated with either groundwater seepage from the site or surface runoff, particularly following heavy rainfalls when the lagoons overflow.

2.4 Observed/Reported Effects of Constituents of Concern

The documentation of visible impacts at the sites provides information regarding actual ecological effects of the constituents measured in potentially harmful quantities, and is useful for validating the conclusions of the risk assessment. An important aspect of the site visits by the field ecologists involved careful examination of inorganic media and biota for evidence of contamination and stress to organisms or mortality caused by the constituents of concern. Historical evidence of contamination was obtained through interviews with refuge biologists and a review of the available site documentation.

No significant adverse ecological impacts were evident at any of the sites visited in July 1993. Evidence of localized aquatic contamination with an oily substance was noted in a drainage ditch at Site 14, but the observed contamination was not associated with any apparent ecological impacts. At Site 16, a wet area contained water with an oily sheen. Vegetation in the wet area appeared normal and there were no other visible signs of impacts. A few small (<30 cm diameter) unvegetated areas were noted at Site 22A during the field reconnaissance. Although these areas were not associated with natural causes such as gravel deposits or standing water, no evidence of contamination was noted and the reason that these areas were unvegetated remains uncertain.

It should be noted that site visits may only uncover ecological effects at a relatively gross scale, and observations are limited to macroscopic flora and fauna. However, since these organisms are dependent upon less visible components of the ecosystem, they can serve as adequate indicators of environmental quality.

Interviews with refuge personnel uncovered the following evidence of historical impacts caused by the constituents of concern. U.S. FWS fisheries biologist C. Surprenant suggested that the elevated incidence of a bacterial disease of fish in Crab Orchard Lake may be an indication of stress caused by chemicals in the lake. In addition, fish consumption advisories have been in effect since 1988 due to elevated levels of PCBs in fish tissues in Crab Orchard Lake.

Previous reports of ecological effects potentially linked to contamination were reviewed by O'Brien and Gere (1988). These were limited to brown patches of vegetation or lack of vegetation at a small number of sites. Observations regarding the presence and location of such effects, made during site visits in July 1993, were in most cases not consistent with those reported in 1988. The transient nature of these observations suggest that the vegetation had recovered from whatever stress caused the brown patches or lack of vegetation noted in 1988. Thus, it is unlikely that these observations were indicative of severe contamination. Rather, they may have been a result of physical damage (e.g., trampling, digging), disease or spills of contaminants that have since decayed or migrated from the site.

3.0 EXPOSURE ANALYSIS

Exposure analysis involves compiling and analyzing pertinent data to determine whether the target compounds may be adversely affecting target organisms on or off-site. Exposure analysis follows a number of steps including:

- identification of significant routes of exposure for contaminants of concern;
- identification of communities or species potentially exposed to contaminants of concern and selection of target species; and
- quantification of exposure of target species to contaminants of concern.

Each of these steps is described in detail below.

3.1 Exposure Routes

A preliminary screening of all sites is given in Section 2.3 along with a discussion of transport and fate processes for the contaminants of concern. That screening process identified 11 sites in which additional analysis is required: Sites 8, 9, 10, 11, 11A, 12, 14, 16, 20, 22A and 36. At these sites, both aquatic and terrestrial biota might be exposed to the constituents of concern. Aquatic organisms are most likely to be exposed through direct contact with contaminated water and ingestion of contaminated water, sediment and food. Terrestrial organisms are most likely to be exposed through ingestion of contaminated drinking water, soil or food. Inhalation of contaminated dust and volatilized substances are generally minor exposure pathways for terrestrial biota. Exposure routes and potential receptors for each of the sites summarized in Table 17 and discussed in detail below.

3.1.1 Site 8

Aquatic and terrestrial organisms, both on and off-site, are potentially at risk from exposure to the volatile organic, MEK, detected in the stream sediment sample. Aquatic organisms could be exposed by direct exposure to the contaminated sediments and by consumption of water, sediment and food both at the site and downstream, where contaminants would be transported. Terrestrial organisms could be exposed through ingestion of potentially contaminated drinking water, soil and food (aquatic prey), and inhalation of potentially contaminated air vapors.

3.1.2 Site 9

It is likely that the one constituent of concern identified for this site, silver, is reflective of the variability of natural soils in this region rather than site contamination. For example, although silver levels recorded in 24 background soil samples ranged from 0.11-0.8 mg/kg (the PLC was based on these samples), levels in four samples from till ranged from 1.81-5.86 mg/kg, which exceeds the level of 1.7 mg/kg recorded in one sample from this site (Golder Associates 1993). With the exception of site 36, silver levels at all sites were also below the minimum value recorded for these till samples. Even so, for the purpose of this preliminary risk assessment, it was conservatively assumed that the silver concentrations measured in samples collected from this site represented site contamination. (The same assumptions are made for all other sites were silver was detected at levels exceeding the PLC).

Aquatic and terrestrial organisms, both on and off-site, are potentially at risk from exposure to the one constituent of concern, silver, that was detected in the stream sediment sample. Aquatic organisms could be exposed by direct exposure to the contaminated sediments and by consumption of water, sediment and food both at the site and downstream, where contaminants would be transported. Terrestrial organisms could be exposed through ingestion of potentially contaminated drinking water, soil and food (aquatic prey).

3.1.3 Site 10

Aquatic and terrestrial organisms, both on and off-site, are potentially at risk from exposure to the one volatile organic, five PAHs, and two metals detected in the stream sediment samples (see Section 2.3.5 for detailed list of constituents). Aquatic organisms could be exposed by direct exposure to the contaminated sediments and by consumption of water, sediment and food both at the site and downstream, where contaminants would be transported. Terrestrial organisms could be exposed through ingestion of potentially contaminated drinking water, soil and food (aquatic plants and animals that bioconcentrate these compounds), and inhalation of vapors potentially contaminated by volatile organics.

3.1.4 Site 11

Aquatic and terrestrial organisms, both on and off-site, are potentially at risk from exposure to the two constituents of concern, arsenic and silver, which were detected in the stream sediment samples. Aquatic organisms could be exposed by direct exposure to the contaminated sediments and by consumption of water, sediment and food both at the site and downstream, where contaminants would be transported. Terrestrial organisms could be exposed through ingestion of potentially contaminated drinking water, soil and food (aquatic plants and animals that bioconcentrate these compounds).

3.1.5 Site 11A

Terrestrial organisms are the primary ones at risk from exposure to the volatile organics, acetone and MEK and the explosive, 2,4,6-trinitrotoluene, identified at this site. These organisms could be exposed through ingestion of potentially contaminated drinking water, soil and food, and inhalation of potentially contaminated air vapors.

Exposure of aquatic organisms to these constituents of concern will be chiefly restricted either to (1) periods during and following heavy rains when potentially contaminated water and soils may run off the site into intermittent or permanent streams or (2) sites where potentially contaminated groundwater discharges into surface water.

3.1.6 Site 12

Aquatic and terrestrial organisms, both on and off-site, are potentially at risk from exposure to the two volatile organics, acetone and MEK, and the two PAHs, phenanthrene and pyrene, detected in the soil samples from this site. Aquatic organisms could be exposed by direct exposure to the contaminated soils and by consumption of water, sediment and food both at the site and downstream, where contaminants might be transported following heavy rains. Terrestrial organisms could be exposed through ingestion of potentially contaminated drinking water, soil and food (plants and animals that bioconcentrate these compounds), and inhalation of vapors potentially contaminated by volatile organics.

3.1.7 Site 14

Both aquatic and terrestrial organisms are potentially at risk from the five volatile organics and eight inorganic compounds detected at this site (see Section 2.3.10 for a detailed list of compounds). Risks to aquatic organisms would be largely restricted to periods following heavy rainfalls when these constituent might be carried off site to an intermittent stream that eventually discharges into Crab Orchard Lake. Terrestrial organisms could be exposed both on and off-site through ingestion of potentially contaminated drinking water, soil and food (plants and animals that bioconcentrate these compounds), and inhalation of vapors potentially contaminated by volatile organics.

3.1.8 Site 16

Both aquatic and terrestrial organisms are potentially at risk from the constituents of concern identified for this site: PCBs, cadmium, copper and silver. Aquatic organisms could be exposed by direct exposure to the contaminated soils and by consumption of water, sediment and food both at the site and downstream, where contaminants might be transported. Terrestrial organisms could be exposed through ingestion of potentially contaminated drinking water, soil and food (plants and animals that bioconcentrate these compounds).

3.1.9 Site 20

Both aquatic and terrestrial organisms are potentially at risk from the two metals, lead and silver detected at this site. Risks to aquatic organisms would be largely restricted to periods following heavy rainfalls when these constituent might be carried off site to a stream that discharges into Crab Orchard Lake. Terrestrial organisms could be exposed both on and off-site through ingestion of potentially contaminated drinking water, soil and food (plants and animals that bioconcentrate these compounds).

3.1.10 Site 22A

Terrestrial organisms are the primary ones at risk from exposure to the volatile organic, PAHs, pentachlorophenol, pesticides, dioxins/furans and metals detected at this site (see

Table 15 for a detailed list of constituents). These organisms could be exposed through ingestion of potentially contaminated drinking water, soil and food, and inhalation of potentially contaminated air vapors.

Exposure of aquatic organisms to these constituents of concern will be chiefly restricted either to (1) periods during and following heavy rains when potentially contaminated water and soils may run off the site into intermittent or permanent streams or (2) sites where potentially contaminated groundwater discharges into surface water.

3.1.11 Site 36

Both aquatic and terrestrial organisms are potentially ones at risk from exposure to the contaminant of concern identified at this site (see section 2.3.18 for a detailed list of constituents). Risks to aquatic organisms occur on site in Dove Creek, the ponds and lagoon and also off-site following heavy rainfalls when these constituent might be carried from the east and west ponds and the lagoons to Quail Creek, which discharges into Crab Orchard Lake. Terrestrial organisms could be exposed both on and off-site through ingestion of potentially contaminated drinking water, soil and food (aquatic plants and animals that bioconcentrate these compounds), and inhalation of potentially contaminated air vapors.

3.2 Receptor Characterization

The objective of this section is to identify the receptor(s) (organism, population, community, ecosystem) at each site that would be most vulnerable to exposure to the contaminants of concern. For this preliminary ecological risk assessment, the focus of receptor characterization is directed towards identification of appropriate target organisms rather than broader ecosystem components, e.g., communities. Target organisms are the focus because quantitative expression of observed effects can be readily derived for specific organisms (e.g., relevant toxicity tests) compared with information required for population, community and ecosystem endpoints (e.g., abundance, biomass, diversity, energy cycling).

Selection of target organisms entails consideration of a number of factors. First, preliminary screening identifies ecosystem components (e.g., aquatic or terrestrial ecosystems, grazers or predators) that are most likely to be affected by the contaminants of concern at each site (Section 3.1). Examination of species lists from the sites provides information on organisms that are :

- potentially sensitive to the contaminants from the site;
- recognized as threatened or endangered;
- migratory and concentrate in the vicinity of the site during certain periods;
- dominant within local biological communities or functioning as keystone species within nearby ecosystems; and
- important commercially or recreational.

Consideration of behavioral and physiologically characteristics can provide further resolution of potential target organisms by focusing on those most likely to be exposed most frequently or most intensively to the contaminants.

The selected representative ecological receptors (i.e., target species) of the ecosystems are discussed below for each site identified as having potential contaminant problems and are summarized in Table 18.

3.2.1 Aquatic Organisms

Aquatic biota are potentially exposed to contaminants from all sites. At some sites (11A, 12, 14, 16, 20, 22A), however, exposure will largely be limited to runoff events when potentially contaminated drainage water enters permanent surface water bodies (streams or lake). At the other sites (8, 9, 10, 11, 36), aquatic organisms are present on site and may potentially be exposed to contaminated water and sediments for prolonged periods. In particular, those aquatic biota that are in direct contact with bottom sediments (e.g., crayfish) and/or feed on benthic organisms (e.g., channel catfish) are the ones at greatest risk. However, specific target organisms for aquatic ecosystems are not required for this preliminary ecological assessment as the hazard assessment is based on water quality criteria that are protective of sensitive aquatic life rather than specific organisms (see Section 4.1).

3.2.2 Terrestrial Organisms

Faunal species of concern were identified based on those animal species that were incidentally observed during the field reconnaissance or those most likely to occur in the vicinity of each site based upon literature review, communications with refuge biologists and availability of habitat types. Target species were then selected based on their predicted exposure frequency and intensity to the know site contaminants; potential sensitivity to the contaminants; population status (i.e., threatened or endangered); commercial or recreational importance; and functional value within the ecosystem.

As was discussed in section 2.1.5, no Federal and Illinois-listed threatened or endangered species were believed to be associated with any specific site. Consequently, none of the identified threatened or endangered species were selected as target species for receptor analyses.

The selected representative target terrestrial receptors were white-tailed deer, raccoon, and american robin. Identifications for their selections are provided below.

3.2.2.1 White-tailed Deer

Because of its recreational importance as a big game species and the abundance of tracks observed on the site during the field reconnaissance, the white-tailed deer was selected as a target indicator species for all sites. White-tailed deer are typically mobile, with home ranges extending between 150 and 400 hectares (ha). Therefore, any given site probably constitutes only a fraction of any given animal's home range. Even so, for this assessment it was conservatively assumed that these sites would provide all of an animals food and water over a short-time period, e.g. one day.

The critical pathways and exposure routes for white-tailed deer on all sites potentially include:

- Ingestion of affected soil,
- Ingestion of affected vegetation, and
- Ingestion of affected surface water.

In addition, at Sites 8, 10, 11A, 12, 14, 22A and 36, deer might be exposed through inhalation of potentially contaminated air vapors.

3.2.2.2 Raccoon

Raccoon populations on the Refuge are relatively high (John Maybery, U.S. FWS, pers. commun.) and the waterbodies in the Refuge contains important aquatic food sources such as crayfish, frogs and fish. Additionally, raccoons feed on mast (e.g., acorns) in the fall and several large oak trees were noted on some sites (e.g., site 10) during the field reconnaissance.

For sites with permanent water bodies (8, 9, 10, 11 and 36), raccoons represent the top predator; and as such, one of the species with the highest potential for accumulative loading of toxins; raccoons were, thus, selected to represent a terrestrial predator for these sites. Indeed, due to their feeding habits and trophic level, they are likely to be exposed to on-site contaminants at these sites more frequently and more intensively than any other terrestrial vertebrate. As with the white-tailed deer, raccoons are fairly mobile, with home ranges extending between 40 and 100 hectares (ha) (Sanderson 1987). Therefore, these sites probably only constitutes a fraction of any given animal's home range. Nonetheless, the sites are potentially important feeding and drinking areas for raccoons and it was conservatively assumed that those sites would provide all of the animals food and water over a short-time period, e.g., one day.

The critical pathways and exposure routes for raccoons at all sites include:

- Ingestion of affected soils and sediments
- Ingestion of affected prey items (i.e., bioaccumulation), and
- Ingestion of affected surface water from the stream.

In addition, at site 8, 10 and 36, raccoons might be exposed through inhalation of potentially contaminated air vapors.

3.2.2.3 American Robin

The other terrestrial species selected as a target species was the american robin. This species was chosen because it represented a predator that could potentially consume all, or the majority of its diet from sites in which terrestrial contamination was of primary concern (Sites 11A, 12, 14, 16, 20, 22A). Higher order predators (i.e., species that feed on american robins such as cooper's hawks) have greater potential for accumulative loading of toxins; but their home ranges are substantially larger than that of american robins and the fraction of their diet acquired from these sites would be negligible. Additionally, the most important prey item of american robins in spring and early summer are earthworms (Lumbricidae), which feed on soil and live in the soil. During wet periods, american robins also could consume all their drinking water from the sites. Consequently, american robins are likely to be exposed to on-site contaminants more frequently and more intensively than any other terrestrial vertebrate. For calculations of exposure, it was assumed that these sites would provide all of the birds food and water over a short time period, e.g., one day.

The critical pathways and exposure routes for american robins on this site include:

- Ingestion of affected soil,
- Ingestion of invertebrates that feed on the affected soil (bioaccumulation), and
- Ingestion of affected surface water after rain showers.

In addition, at Sites 11A, 12, 14, 16 and 22A inhalation of contaminated vapors is a potential exposure pathway.

3.3 Exposure Quantification

3.3.1 Aquatic Organisms

A large database of toxicological information is available for freshwater aquatic organisms; thus, exposure assessments for aquatic organisms invariably utilize toxicity data for assessment endpoints. Quantification of exposure of aquatic organisms is, therefore, based on contaminant concentrations that might be expected in surface waters.

Surface waters were not sampled at any of the Misc AOU sites, so no direct measurements of surface water concentrations are available. It is possible, however, to estimate surface water concentrations of the organic constituents of concern based on chemical characteristics and assumptions about surface runoff patterns and receiving water quality. For instance, concentrations of organic contaminants dissolved in water (C_{diss}, mg/L), which is in equilibrium with sediments, can be estimated from sediment contaminant concentrations (C_{soil}, mg/kg) and the partition coefficient (k_d, dimensionless):

$$C_{diss}=\frac{C_{soil}}{k_d} \tag{1}$$

where

$$k_d = f_{oc}\,K_{oc} \tag{2}$$

and f_{oc} is the fraction of organic carbon in the sediments (dimensionless) and K_{oc} is the organic carbon/water partition coefficient (dimensionless). K_{oc} can be estimated from the octanol/water partition coefficient, K_{ow} , according to a relationship given by Schwarzenbach and Westall (1981):

$$\log K_{oc} = 0.72 \log K_{ow} + 0.49 \tag{3}$$

In addition to contaminants dissolved in water, contaminants might also be bound to dissolved and particulate organic matter in the water. Concentrations of contaminants bound to organic carbon (C_{oc}, mg/L) may be estimated from:

$$C_{oc} = C_{diss}\,K_{oc}\,TOC\,10^{-6} \tag{4}$$

where TOC (mg/L) is the concentration of total organic carbon in the water column and 10^{-6} is a factor that convert units for organic carbon from mg/L TOC to kg/L TOC (i.e., sediment concentrations are given in units of mg contaminant per kg organic carbon and TOC in units of mg organic carbon per liter of water).

Thus, total water column contaminant concentrations (C_{wc}, mg/L) are simply:

$$C_{wc} = C_{diss} + C_{oc} \tag{5}$$

C_{wc} represents the concentration of contaminant that might be expected if water was in complete equilibrium with the contaminated sediments and was not diluted with other sources of uncontaminated water. In cases where dilution with uncontaminated water will occur prior to exposure to target organisms, a dilution factor, Q_{cont} / Q_{back}, can be multiplied to C_{wc} prior to comparing to critical values. (Q_{cont} and Q_{back} are the volumes of contaminated and natural background water, respectively, expected at or downstream of each site, Appendix III).

In contrast to organic constituents, no simple relationships exist to estimate concentrations of metals that might be dissolved in water from concentrations measured in sediments. Metal solubility and speciation depends on the interacting effects of a local environmental conditions, e.g., pH, organic matter, hardness, redox. Site-specific data are, therefore, necessary to accurately assess water column metal concentrations. These data are not available for this preliminary risk assessment so conservative assumptions have been applied to derive water column metal concentrations.

The dissolved fraction of metals in the water column can be estimated from Eq. (1) where k_d is a conservative estimate of partitioning between the dissolved and particulate metal fractions. Values for k_d have been estimated from the literature (Table 14).

Both aquatic plants and animals may accumulate contaminants in tissue. The bioconcentration factor (BCF) represents the ratio of the chemical concentration in the animal or plant tissue divided by its concentration in water (aquatic organisms), food (terrestrial animals) or soil (terrestrial plants) (U.S. EPA 1988). Bioconcentration factors for organic compounds and metals have been reported for a number of organisms and these factors can be used along with exposure concentrations derived as outlined above (i.e., C_{wc} or C_{soil}) to estimate contaminant levels in plant and animal tissue (C_{plant} and C_{animal}, respectively in mg/kg):

$$C_{plant} = BCF_{plant} \, C_{soil} \tag{6}$$

and

$$C_{animal} = BCF_{animal} \, C_{wc} \tag{7}$$

It was assumed that these animals and plants were in direct and constant contact with the contaminated media, so exposure concentrations were not corrected for dilution with uncontaminated media. The use of published BCFs is suggested by the U.S. EPA (1988) where there are insufficient data to develop site-specific BCFs. There is uncertainty with the use of published BCFs, however, as they vary depending upon contaminants, site conditions and species. For these reasons, the highest BCFs reported in the literature were used here.

3.3.2 Terrestrial Organisms

Terrestrial organisms are most likely to be exposed to contaminants through ingestion of contaminated drinking water, soil or food. Inhalation of contaminated dust and volatilized substances are generally minor exposure pathways for terrestrial biota. For this preliminary risk assessment, inhalation was only considered for those sites in which volatile organics were detected, and inhalation of dust was presumed to be negligible (due to grass cover and aquatic environments) and was not assessed.

Total daily intake (TDI, mg/kg-BW/d) of contaminants by terrestrial organisms was computed from:

$$TDI = EDI_{soil} + EDI_{water} + EDI_{food} \tag{8}$$

where EDI_{soil}, EDI_{water}, and EDI_{food} are the estimated daily intakes due to soil ingestion, drinking water and food, respectively, in units of mg contaminant ingested per kg body weight (BW) per day. Daily ingestion rates for each of these intake routes are computed according to:

$$EDI_{soil}=\frac{C_{soil}R_{soil}F_{soil}}{BW} \tag{9}$$

$$EDI_{water}=\frac{C_{wc}R_{water}F_{water}}{BW} \tag{10}$$

$$EDI_{food}=\frac{(C_{plant}R_{plant}F_{plant}+C_{animal}R_{animal}F_{animal})}{BW} \tag{11}$$

where R_{soil}, R_{water}, R_{plant} and R_{animal} are the ingestion rates of soil, water, vegetation and prey, respectively, as noted in Appendix III (kg wet weight per day, except water, L/d); and

F_{soil}, F_{water}, F_{plant} and F_{animal} are the fractions of soil, water, vegetation and prey, respectively derived from the site (dimensionless), which was conservatively set at 1 for this assessment.

In addition to ingestion of contaminants, terrestrial organisms at those sites where volatile organics were detected might inhale potentially contaminated air. Vapor concentrations in the soil voids (C_{air}, mg/m^3) can be estimated according to an equation given by Scott and Hetruck (1993):

$$C_{air}=\frac{C_{diss}\ H\cdot 10^{-3}}{R(T+273)} \tag{12}$$

where H is Henry's Law constant (m^3-atm/mol);

$\underline{R}$ is the gas constant ($8.2x10^{-5}$ m^3-atm/mol/K);

$\underline{T}$ is the soil temperature (°C); and

10^{-3} converts $\underline{C_{diss}}$ units from mg/L to mg/m^3.

This is an extremely conservative analysis of the inhalation pathway as dilution with uncontaminated air was not accounted for in these estimates of exposure concentrations. This equation does not hold for miscible organics, so vapor concentrations of acetone were not predicted for this study.

4.0 TOXICITY ASSESSMENT

In this section of the report, available toxicological data are compiled for each constituent of concern and for aquatic and terrestrial receptors. The organism is the focus of this preliminary risk assessment because of the large numbers of toxicological data available for individual organisms and the relative ease of interpreting responses of single organisms compared with higher levels, e.g., communities.

4.1 Aquatic Organisms

A large database of toxicological information is available for freshwater aquatic organisms; thus, exposure assessments for aquatic organisms invariably utilize toxicity data for assessment endpoints. For some constituents, this information has already been integrated and formulated into specific water quality criteria, e.g., U.S. EPA (1986) Quality Criteria for Water, which are designed to protect 95 percent of all aquatic organisms. Where available, published criteria pertaining to chronic toxic effects were used to define the critical toxicity values (CTV) for aquatic life.

For constituents in which water quality criteria have not been established, critical toxicity values were derived as follows:

- aquatic toxicity data were reviewed using the U.S. EPA's Aquatic Information Retrieval (AQUIRE) database to identify the no-observed effect level (NOEL) for freshwater fish or amphibians, and that value was used as the CTV for aquatic life;

- if no NOEL results were available, then the CTV was based on the lowest reported value for freshwater fish or amphibians from either chronic or acute tests. Safety factors of 5 and 10 were used to extrapolate to NOEL from results of the chronic and acute tests, respectively. (A value of 10 has been suggested to convert acute to NOEL (chronic) levels (U.S. EPA 1990). And, given that on NOEL is the next dilution below which an observed effect was recorded, a safety factor of 5 should be very conservative when extrapolating from chronic to NOEL values.

The critical toxicity values used in this assessment are given in Table 19.

4.2 Terrestrial Wildlife

Toxicity data (oral dose and air concentration) for terrestrial wildlife were obtained from the US National Institute of Occupational Safety and Health's Registry of Toxic Effects of Chemical Substances (RTECS) database (Tables 20 and 21). That database includes toxicity data, primarily from mammals for most of the constituents of concern. There are fewer toxicity data for terrestrial wildlife than for aquatic organisms and very few data for the target organisms selected for this study. Therefore, it was often necessary to extrapolate toxicity data derived from other animal species. Because of the uncertainties in this extrapolation, a safety factor of 5 was used for constituents where species to species extrapolations were made. Similarly, correction factors of 5 and 10 were applied when extrapolating to NOEL from chronic and acute toxicity tests, respectively (see section 4.1 for rationale of these safety factors). There are too few data to develop specific criteria for individual species. Therefore the criteria developed here are generic in nature and were applied to all terrestrial, wildlife receptors.

Criteria recommended by U.S. FWS in their "Contaminant Hazard Reviews" are also included in Table 20. In some cases, these values were used when no information was available in RTECS. Where values from both the U.S. FWS and RTECS were available, the lowest one was used to derive the CTV for a particular constituent.

4.3 Vegetation

The effects of man-made chemicals on terrestrial plants have not been extensively studied. Existing data compiled in the PHYTOTOX database (U.S. EPA) focuses on pesticides and herbicides applied to leaves of common agricultural crops. As a result, quantitative toxicity data for most plant species present in Crab Orchard NWR are not available.

The primary concern regarding toxicity to plants in the refuge is the potential toxic effect of constituents taken up from soils through the roots. Although the amount of chemical bioaccumulated through root uptake may be estimated using the regression equation based on $\underline{K_{OW}}$ (Travis and Arms 1988), no information is available regarding the toxicity of chemicals present in plant tissues. Uptake of volatile chemicals by the foliage has also been documented to result in elevated levels of organochlorines in plant tissues in areas with significant aerial contamination (Buckley 1982). However, there are no data regarding aerial levels of constituents in the study area, or the relationship between levels in air and plant tissues. As the result of the above data gaps, a quantitative assessment of terrestrial plant toxicity cannot be conducted.

In the absence of specific information, criteria derived for aquatic organisms were used to provide a qualitative estimate of the potential for terrestrial plant toxicity. These criteria are generally protective of both aquatic animal and plant species.

5.0 RISK CHARACTERIZATION

Potential risks to target organisms are quantified in this assessment by the quotient method, where the Ecological Risk Index (ERI) is computed for aquatic and terrestrial organisms at each site as:

$$ERI_{aq,sum}=\sum_{i=1}^{i=n} C_{wc,i}\,/CTV_{water,i} \tag{13}$$

where $ERI_{aq,sum}$ is the total risk to aquatic biota at each site;

$C_{wc,i}$ is water column concentration of contaminant i;

CTV is the critical toxicity value for aquatic biota for contaminant i; and

n is the total number of contaminants at each site.

And the ERI is computed for terrestrial organisms as:

$$ERI_{t,sum}=\sum_{i=1}^{i=n} (TDI_i\,/CTV_{ing,i}+C_{air,i}\,/CTV_{inh,i}) \tag{14}$$

where $ERI_{t,sum}$ is the total risk to terrestrial receptors at each site;

TDI_i is the total daily intake of contaminants due to ingestion (all pathways);

$CTV_{ing,i}$ is the CTV for ingestion for contaminant i;

$CTV_{inh,i}$ is the CTV for inhalation for contaminant i; and

$C_{air,i}$ is vapor concentration of contaminant i.

Note that the ERI_{sum} is computed based on the assumption that risks associated with both a mixture of n different chemicals and the different exposure pathways analyzed are additive. If ERI_{sum} exceeds 1.0, then the target organism may be at risk to adverse effects from the total exposure associated with all constituents and all exposure pathways. Given that conservative estimates were utilized in quantification of both the exposure concentrations and doses and in the derivation of critical toxicity values, an ERI_{sum} greater than 1.0 does not necessarily imply that an adverse effect will occur, rather it indicates the possibility that an adverse effect might occur and that additional work is necessary to more accurately quantify the risk.

In the following subsections, the findings of the risk calculations are discussed on a site-by-site basis. For each site, ERIs are reported for each constituent of concern and each applicable target organism. In addition to ERI_{sum}, ERIs computed for each medium and each constituent are reported, which provide information on the particular chemical and transport medium associated with the greatest ecological risk.

All assumptions used in the exposure calculations are given in Appendix III and computed exposure concentrations and doses are given in Appendix IV.

5.1 Uncertainties Associated with the Assessment

There are a number of sources of uncertainty at each stage of the ecological risk assessment. The four major categories of uncertainty are (1) incomplete knowledge of the system studied, (2) natural variability in physical and biological processes, (3) characteristics of the data upon which the assessment is based, and (4) errors in executing the assessment (U.S. EPA 1992, Suter 1993).

Uncertainty introduced during exposure assessment included the use of relatively few data to estimate concentrations in environmental media, the variability of chemical analytical data, assumptions concerning the environmental distribution and fate of constituents and ecological characteristics at the sites and receptor organisms, and natural variability. The use of replicate samples with consistent analytical results to represent typical concentrations at the sites sampled and appropriate laboratory QA/QC procedures during chemical analyses minimizes the amount of uncertainty associated with the former two sources. All assumptions regarding constituent distribution and fate and the ecology of receptor organisms were made to reflect the worst case exposure scenario, e.g., maximum reported concentration used, no fate processes modelled. Natural variability undoubtedly contributes to the total uncertainty associated with the assessment but cannot be adequately accounted for without more quantitative techniques. However, in light of the conservative assumptions used throughout the exposure assessment, the contribution from this course is likely to be minor.

Results of the ecological effects assessment may be influenced by uncertainty contributed by the use of toxicity data generated under controlled environmental conditions to represent effects in the natural environment, variability in sensitivities of toxicity test organisms, and the use of toxicity data for surrogate organisms in the absence of data for local fauna. Toxicity values compiled by the U.S. EPA and U.S. FWS were used throughout the assessment. To ensure a conservative result, toxicity values for the most sensitive surrogate organism were used (with an appropriate safety factor applied).

The end result of the above procedures and assumptions made during the assessment is that any errors in the degree of estimated risk caused by uncertainty are in the direction of predicting a greater than actual ecological effect. This conservative approach is a necessary requirement of a preliminary screening assessment, and ensures that sites with a potential for adverse ecological effects are not excluded from further investigation.

5.2 Ecological Risks

5.2.1 Background Soil Samples

As noted above, conservative assumptions are used throughout this preliminary ecological risk assessment. One consequence of this conservative approach is that risk quotients (i.e., ERIs), are greater than 1.0 for most metals, even when computed from naturally-occurring levels (Table 22). This, of course, does not imply that organisms are at risk from metals associated with natural soils in the region, rather, it further illustrates the very conservative nature of this assessment.

Since ERIs for metals recorded at background sites exceed 1.0, there is no need to compute risks for any sites where these metals were identified as constituents of concern; i.e., PLCs for metals were set equal to or greater than background levels (Table 10), thus, ERIs computed at any site where metals were identified as constituents of concern would exceed 1.0. However, because of the potential hazards associated with some metals, additional work is recommended to (1) determine the source of the metals and (2) better quantify environmental concentrations and assumptions used in this assessment (see Section 6.0).

5.2.2 Site 8

The findings of this evaluation suggest that there is be little likelihood of ecological risks to either aquatic biota or terrestrial wildlife from exposure to the constituent of concern, MEK, identified for this site (Table 23).

5.2.3 Site 9

Risks associated with the one constituent of concern, silver, were not quantified as ERIs computed from background levels of silver exceeded 1.0 for all receptors (see Section 5.2.1; Table 22).

5.3.4 Site 10

Terrestrial and aquatic organisms may be exposed to the constituents of concern both on and off-site. The ERIs computed for this site are given in Table 24. The findings of this evaluation suggest that there appears to be little potential for risk to white-tailed deer (ERI_{sum} 0.186). There is, however, potential risk to raccoons and aquatic life (ERI_{sum} 3.97 and 4.45, respectively). The risks to raccoons are associated with consumption of food potentially tainted with benzo(a)anthracene, while risks to aquatic life are chiefly associated with the PAHs, benzo(a)anthracene, benzo(b)fluoranthene and fluoranthene. Risks associated with the two metals identified as constituents of concern, cadmium and silver, were not quantified as ERIs computed from background levels of these metals exceeded one for all receptors (see Section 5.2.1; Table 22).

5.2.5 Site 11

Risks associated with the two constituents of concern, arsenic and silver, were not quantified as ERIs computed from background levels of these constituents exceeded one for all receptors (see Section 5.2.1; Table 22).

5.2.6 Site 11A

Terrestrial organisms may be exposed to the constituents of concern both on and off-site while exposure to aquatic organisms will be chiefly limited to off-site locations during and following runoff events. The ERIs computed for this site are given in Table 25. The risk indices derived for this site indicate little potential for adverse effects to either terrestrial wildlife (ERI_{sum} for white-tailed deer and robins are 0.142 and 0.769, respectively) or aquatic life (ERI_{sum} 0.199). Risks associated with the one metal identified as constituent of concern, silver, were not quantified as ERIs computed from background levels of silver exceeded one for all receptors (see Section 5.2.1; Table 22).

5.2.7 Site 12

Terrestrial organisms may be exposed to the constituents of concern both on and off-site while exposure to aquatic organisms will be chiefly limited to off-site locations during and following runoff events. The ERIs computed for this site are given in Table 26. The risk indices derived for this site indicate little potential for risk to white-tailed deer (ERI_{sum} 0.0896) or aquatic life (ERI_{sum} 0.208). There is, however, potential risk to robins associated with consumption of food tainted by phenanthrene and pyrene (ERI_{sum} 2.94). Risks associated with acetone and silver were not quantified as vapor concentrations for acetone were not computed (Section 3.3.2) and ERIs computed from background levels of silver exceeded 1.0 for all receptors (see Section 5.2.1; Table 22).

5.2.8 Site 14

Terrestrial organisms may be exposed to the constituents of concern both on and off-site while exposure to aquatic organisms will be chiefly limited to off-site locations during and following runoff events. The ERIs computed for this site are given in Table 27. There is potential risk to all receptors as ERI_{sum} for white-tailed deer, robins and aquatic biota are 169, 6430 and 83.3, respectively. Risks to both deer and robins are primarily associated with exposure to volatile organics via inhalation of contaminated air and through ingestion of food tainted potentially tainted with cyanide. Risk to aquatic biota are limited to potential exposure to cyanide. In addition to the constituents listed in Table 27, seven metals were identified as constituents of concern (Section 2.3.10). As noted in Section

5.2.1, risks associated with these metals were not quantified as ERIs computed from background levels exceeded 1.0 for all receptors (Table 22).

5.2.9 Site 16

Terrestrial organisms may be exposed to the constituents of concern both on and off-site while exposure to aquatic organisms will be chiefly limited to off-site locations during and following runoff events. The ERIs computed for this site are given in Table 28. There is little likelihood of risk to deer (ERI_{sum} 0.0731). However, there is potential risk to robins and aquatic biota as a result of exposure to PCBs (ERI_{sum}'s are 126,000 and 529, respectively). Risk to terrestrial predators is primarily a result of ingestion of tainted prey. As noted in Section 5.2.1, risks associated with the three metals identified as constituents of concern, cadmium, copper and silver, were not quantified as ERIs computed from background levels exceeded 1.0 for all receptors (Table 22).

5.2.10 Site 20

Risks associated with the two constituents of concern, lead and silver, were not quantified as ERIs computed from background levels of these metals exceeded 1.0 for all receptors (see Section 5.2.1; Table 22).

5.2.11 Site 22A

Terrestrial organisms may be exposed to the constituents of concern both on and off-site while exposure to aquatic organisms will be chiefly limited to off-site locations during and following runoff events. The ERIs computed for this site are given in Table 29. There is little risk to deer (ERI_{sum} 0.791), but potential risk to robins and aquatic biota (ERI_{sum} 5.6×10^5 and 53.6, respectively). Risks to robins are primarily associated with exposure to dioxins/furans via ingestion of potentially tainted food. Risks to aquatic biota are associated with potential exposure to DDT and dioxins/furans. In addition to the constituents listed in Table 29, four metals were identified as constituents of concern: cadmium, manganese, mercury and silver. As noted in Section 5.2.1, risks associated with these metals were not quantified as ERIs computed from background levels exceeded 1.0 for all receptors (Table 22).

5.2.12 Site 36

Dove Creek

Terrestrial and aquatic organisms may be exposed to the constituents of concern, both on and off-site. The ERIs computed for this site are given in Tables 30. The risk indices derived for this site indicate little likelihood of risk to white-tailed deer (ERI_{sum} 0.009). There is, however, potential risk to terrestrial predators and aquatic biota as a result of exposure to PCBs (ERI_{sum}'s are 199 and 584, respectively). In addition to the constituents listed in Table 30, six metals were identified as constituents of concern (Section 2.3.18). As noted in Section 5.2.1, risks associated with these metals were not quantified as ERIs computed from background levels exceeded 1.0 for all receptors (Table 22).

West Pond

Risk associated with the two constituents of concern, cadmium and silver, were not quantified as ERIs computed from background levels exceeded 1.0 for all receptors (see Section 5.2.1; Table 22).

East Pond

Terrestrial and aquatic organisms may be exposed to the constituents of concern, both on and off-site. The ERIs computed for this site are given in Tables 31. There is potential risk to all receptors as ERI_{sum} for white-tailed deer, raccoons and aquatic biota are 25.1, 1730, and 4550, respectively. Risks to deer are restricted to inhalation of potentially contaminated vapors. Risks to raccoons are primarily associated with consumption of tainted food, particularly food potentially contaminated with PAHs, aldrin and PCBs. Risks to aquatic biota are associated with exposure to these same constituents. In addition to the constituents listed in Table 16, ten metals were identified as constituents of concern. As noted in Section 5.2.1, risks associated with these metals were not quantified as ERIs computed from background levels exceeded 1.0 for all receptors (Table 22).

Primary Lagoon

Terrestrial and aquatic organisms may be exposed to the constituents of concern, both on and off-site. The ERIs computed for this site are given in Tables 32. The risk indices derived for this site indicate little potential for adverse effects to white-tailed deer (ERI_{su} 0.013). There is, however, potential risk to raccoons and aquatic biota as a result of exposure to PCBs (ERI_{sum} 3.81 and 11.2, respectively).

5.2.13 Vegetation

As discussed in section 4.3, assessment of risks to vegetation was based on a qualitative evaluation of vegetation during the July, 1993 site inspection. With the exception of a small (<30 cm diameter) unvegetated area noted at Site 22A all vegetation appeared healthy. It must be stressed, however, that visual inspection may only identify ecological effects at a rather gross scale, and observations are limited to macroscopic flora.

6.0 RECOMMENDATIONS

The following are specific recommendations, on a site-by-site basis, of the need for further studies (if any) to more accurately define ecological risks.

6.1 Sites 7, 7A, 8, 13, 18, 21, 27, 35

The findings of the site inspections and preliminary screening based on contaminant concentrations measured as part of the sediment and soil sampling programs indicate that there is little likelihood of potential ecological risk at these sites. Thus, no further assessment is recommended for these sites.

6.2 Site 9

Silver was the only constituent of concern identified for this site. Like all inorganic constituents (except antimony) that were measured at values above their PLCs, silver is a potential hazard to ecological receptors. However, three factors suggest that the silver levels recorded at this site (and most other sites) are a reflection of natural soil variability rather than evidence of site contamination: (1) silver concentrations recorded at most study sites (except 36-East Pond) were only marginally above levels reported for background soil samples, (2) silver concentrations at all sites (except Site 36-East Pond) were within the range reported for other media collected from background sites (e.g., till), thus, there are natural sources of silver in the study area, and (3) there is no obvious anthropogenic source of silver in this area. Notwithstanding the probability that the levels of silver at this site are reflective of natural variability, additional assessment of silver (and other metals) is recommended at selected study sites (10, 14, 16, 22A and 36). In particular, data collected from Site 10 (Section 6.3) will provide additional information required to further assess potential risks associated with silver at this site (since Site 9 drains into Site 10).

6.3 Site 10

Potential ecological risks at this site are associated with exposure of terrestrial predators to benzo(a)anthracene and aquatic organisms to the PAHs, benzo(a)anthracene, benzo(b)fluoranthene, and fluoranthene and possibly the metals cadmium and silver. However, given the very conservative nature of the assumptions used to estimate risk and the low risk indices that was computed (ERI$_{sum}$ 4.0 and 4.5 for raccoon and aquatic biota, respectively) more information is required to confirm whether these constituents actually poses an ecological risk.

As a first step, the presence of contaminants need to be confirmed with a more spatially intensive sampling program to delineate the zone of contamination. Even though aquatic life are most at risk at this site, sampling for non-volatile organics should be largely restricted to solid-phase media, e.g., stream bottom sediments rather than surface water or groundwater, because PAH concentrations in water would only be a small fraction of that in the solid phase (given the high K_{ow} of these compounds; Table 12), and concentrations in water would likely be below analytical detection limits.

Initially, three composite samples should be collected from stream sediments along a transect extending from upstream of the site (background) where contaminants were detected during Phase I sampling to Crab Orchard Lake. Samples should be collected from near the sediment-water interface and in depositional areas (e.g., beaver pond). One of the composite samples should be collected from Crab Orchard Lake sediments at the site where the stream enters the lake. All samples should be analyzed for semi-volatile organics, inorganic analytes and total organic carbon. A solid-phase toxicity tests(s) could be utilized to directly measure toxicity, e.g., Microtox, Chrinomas tentans, Hyalella azteca.

Two stream water samples should be collected and analyzed for the same parameters as the sediment samples plus pH and hardness to confirm the predicted low levels of contaminants in the surface water. The samples should be collected during low flows, when surface waters are not diluted with vast amounts of upstream runoff. One sample should be collected upstream of the site of contaminated sediments and the other immediately downstream.

In addition, it would be valuable to analyze tissue residues from benthic organisms that are in direct contact with the contaminated sediments, particularly those that (1) scavenge detritus, (2) have a relatively small home range, and (3) are of sufficient size or densities to easily collect adequate amounts of sample for analysis (e.g., crayfish). Tissue concentrations provide an integrator of sediment and water-borne contaminants and thus may serve as an independent indicator of contamination. These measurements will also provide an indication of bioconcentration to compare against literature-derived estimates and those used in this preliminary risk assessment. Three sets of tissue samples should be analyzed; a background sample collected upstream of the site; one collected at or near the site of contamination identified in Phase I sampling; and one from Crab Orchard Lake near the site where the stream enters the lake. These sites should coincide with sites where bottom sediment samples are collected.

6.4 Site 11

Arsenic and silver was the only constituents of concern identified for this site. Like all inorganic constituents (except antimony) that were measured at values above their PLCs, arsenic and silver are potential hazards to ecological receptors. However, as noted for Site 9, it is likely that the silver levels recorded at this site are a reflection of natural soil variability rather than evidence of site contamination since: (1) arsenic and silver concentrations were only marginally above levels reported for background soil samples, (2) arsenic and silver concentrations were within the range reported for other media collected from background sites (e.g., till), thus, there are natural sources of arsenic and silver in the study area, and (3) there is no obvious anthropogenic source of arsenic and silver at this site. Notwithstanding the probability that the levels of arsenic and silver at this site are reflective of natural variability, additional assessment of metals is recommended at selected study sites (10, 14, 16, 22A and 36). These data will provide additional information required to further assess potential risks associated with arsenic and silver at this site.

6.5 Site 11A

The findings of this preliminary risk assessment indicate that there is little likelihood of ecological risk from the organic constituents of concern detected at this site. One possible exception is acetone, as ERIs were not computed for this constituent. However, the vapor sampling program recommended for Site 14 will provide pertinent data to assess risks associated with acetone (and other volatile organics). Consequently, no further sampling of organics is recommended for this site. Like most other sites, silver also exceeded its

PLC. Since Site 11A drains into Site 10, data collected from that site (see Section 6.3) will provide additional information that can be used to further assess potential risks associated with silver at Site 11A.

6.6 Site 12

The findings of this preliminary risk assessment indicate that there is little likelihood of ecological risk to deer or aquatic biota from the organic constituents of concern detected at this site. One possible exception is acetone, as ERIs were not computed for this constituent. However, the vapor sampling program recommended for Site 14 will provide pertinent data to assess risks associated with acetone (and other volatile organics). Robins are potentially at risk from consumption of food tainted with PAHs. Data collected from sites 10, 16 and 22A will provide useful information to better quantify tissue concentrations in prey, i.e., values for BCFs would be obtained from the sampling programs recommended for those sites. Consequently, no further sampling of organics is recommended for this site. Like most other sites, silver also exceeded its PLC. Data collected from Sites 10, 14, 16, 22A and 36 will provide additional information required to further assess potential risks associated with silver at this site.

6.7 Site 14

Ecological risks at this site are due to potential exposure of aquatic biota to cyanide and metals and terrestrial organisms to contaminated air (volatile organics) and tainted food (cyanide and metals). However, the exposure concentrations used in this preliminary assessment are gross overestimates of those that would actually be present at the site (i.e., exposure concentrations were computed for air in direct contact with contaminated soils and did not include dilution effects) and need to be better quantified.

As a first step, the zone of volatile organic contaminants needs to be confirmed with a more spatially intensive sampling program (e.g., soil vapor sampling program). Once delineated, air concentrations of the volatile organics could be directly measured. Potential exposure of aquatic organisms to site contaminants should be directly measured by collecting surface water samples from two sites: one should be located along the intermittent stream that collects runoff water from the site and another along the permanent stream into which the intermittent stream drains. The surface water samples should be analyzed for volatile organics and inorganic analytes. Data collected from Sites 10, 16, 22A and 36 will provide useful information to better quantify contaminant levels in prey such as earthworms.

6.8 Site 16

Ecological risks at this site are a result of potential exposure of terrestrial predators (due to consumption of tainted prey) and aquatic biota to PCBs and possibly metals. An oily sheen was also noted at a wet area east of the site where sample 16-3 was taken, and additional samples need to be collected to identify the source of this apparent contamination.

Contaminant levels in prey should be directly measured to confirm this exposure pathway for terrestrial predators. This is easily accomplished by sampling prey that are in direct contact with soil contaminants (e.g., earthworms) and submitting for tissue residue analysis of PCBs and metals. Soil samples should be collected from the same sites where earthworms are collected and one set of samples needs to be collected from a natural background site.

Potential exposure of aquatic organisms to site contaminants should be directly measured by collecting surface water samples from two sites: one should be located along the intermittent stream that collects runoff water from the site and another along the permanent stream into which the intermittent stream drains. The surface water samples should be analyzed for PCBs and inorganic analytes.

6.9 Site 20

Lead and silver was the only constituents of concern identified for this site. Like all inorganic constituents (except antimony) that were measured at values above their PLCs, these metals are a potential hazard to ecological receptors. Notwithstanding the possibility that the levels of lead and silver at this site are reflective of natural variability, additional assessment of metals is recommended at selected study sites (10, 14, 16, 22A and 36). In particular, data collected from Site 10 (Section 6.3) will provide additional information required to further assess potential risks associated with lead and silver at this site (since Site 20 drains into the stream at Site 10).

6.10 Site 22A

There are potential ecological risks at this site as a result of exposure to dioxins/furans and possibly metals; DDT is also a potential hazard to aquatic biota. Risks to terrestrial wildlife are chiefly associated with consumption of tainted food. Therefore, the contaminant levels in food should be directly measured to confirm this exposure pathway. This is easily accomplished by sampling food that is in direct contact with soil contaminants and submitting for tissue residue analysis, e.g. vegetation, earthworms. Four discrete areas should be sampled, i.e., those three sites west of the former shop and maintenance yard in which elevated dioxin/furan levels were detected during the Phase I sampling plus one background site. All tissue samples should be analyzed for inorganic analytes, semi-volatile organics and dioxins/furans.

Potential exposure of aquatic organism to site contaminants should be directly measured by collecting surface water samples from two sites: one should be located along the intermittent stream that collects runoff water from the site and another along the permanent stream (Pigeon Creek) into which the intermittent stream drains. The surface water samples should be analyzed for inorganic analytes, semi-volatile organics, and dioxins/furans.

6.11 Site 36

Site 36 represents the most highly impacted of all sites investigated (in terms of the number of constituents of concern), and exposure to contaminants from this site is a potential risk to both terrestrial and aquatic organisms. Future studies at this site should focus on (1) delineating the downstream extent of the zone of contamination on Dove Creek and Pigeon Creek, (2) assessing the effect of discharges from the site on Crab Orchard Lake, (3) quantifying off-site discharges from the East Pond, and (4) determining whether site contamination is a result of historical or ongoing plant operation. Sampling of all media (sediments, water, plant and animal tissues) plus toxicological tests would be appropriate.

7.0 REFERENCES

Baudo, R., J.P. Giesy and H. Muntau. 1990. Sediments: Chemistry and Toxicity of In-Place Pollutants. Lewis Publishers. Chelsea, Michigan. 405 pp.

Behler, J.L. and F.W. King. 1979. The Audubon Society field guide to North American reptiles and amphibians. Alfred A. Knopf, New York, N.Y. 719 pp.

Black, J.A., W.J. Birge, W.E. McDonnell, A.G. Westerman, B.A. Ramey and D.M. Bruser. 1982. The Aquatic Toxicity of Organic Compounds to Embryo-Larval Stages of Fish and Amphibians. Water Resour. Res. Instl, Res. Rep. No 133, Univ. of Kentucky, Lexington, KY; U.S. NTIS PB82-224601: 61 p.

Black, J.A., W.J. Birge, A.G. Westerman and P.C. Francis. 1983. Comparative Aquatic Toxicology of Aromatic Hydrocarbons. Fundam. Appl. Toxicol. 3(9/10):353-358.

Boyle, R.W. 1968. The geochemistry of silver and its deposits. Geol. Surv. Can. Bul. No. 160.

Buckley, E.H. 1982. Accumulation of airborne polychlorinated biphenyl in foliage. Science. 216:520-522.

Canadian Council of Ministers of the Environment. 1991. Interim Canadian Environmental Quality Criteria for Contaminated Sites. The National Contaminated Sites Remediation Program. Report CCME EPC-CS34.

Canadian Council of Resource and Environment Ministers (CCREM). 1987. Canadian Water Quality Guidelines. Prepared by Task Force on Water Quality Guidelines.

Carlson, R.M. A.R. Oyler, E.H. Gerhart, R. Caple, K.J. Welch, H.L. Kopperman, D. Bodenner and D. Swanson. 1979. Implications to Aquatic Environment of Polynucear Aromatic Hydrocarbons Liberated from Northern Great Plains Coal. EPA-600/3-79-093, Environ. Res. Lab., U.S. EPA, Duluth, MN:156 P.

Cook, P.M., D.W. Kuehl, M.K. Walker and R.E. Peterson. 1991. Bioaccumulation and toxicity of TCDD and related compounds in aquatic ecosystems. In Biological Basis for Risk Assessment of Dioxins and Related Compounds (ed. Gallo et al.). p143-167. Cold Spring Harbor Laboratory Press 0-87969-235-9/91.

Defoe, D.L., G.D. Veith and R.W. Carlson. 1978. Effects of Aroclor 1248 and 1260 on the Fathead Minnow. J. Fish Res. Board Can. 35(7):997-1002.

Dill, D.C, P.G. Murphy and M.A. Mayes. 1987. Toxicity of Methylene Chloride to Life Stages of the Fathead Minnow, Pimephales promelas Rafinesque. Bull. Environ. Contam. Toxicol. 39(5):869-876

Earnest, R. 1974. Acute toxicity of twenty insecticides to striped bass, Morone saxatilis. Calif. Fish. Game 60:128-131.

Eisler R. 1985. Cadmium hazards to fish, wildlife and invertebrates. A synoptic review. U.S. Fish and Wildlife Services Contaminant Hazard Review. Report No. 2.

Eisler, R. 1986. Chromium hazards to fish, wildlife and invertebrates: A synoptic review. U.S. Fish and Wildlife Service. Contaminant Hazard Report No. 6.

Eisler R. 1988. Arsenic hazards to fish, wildlife and invertebrates: A synoptic review. U.S. Fish and Wildlife Services Contaminant Hazard Review. Report No. 12.

Eisler R. 1991. Cyanide hazards to fish, wildlife and invertebrates: A synoptic review. U.S. Fish and Wildlife Service. Contaminant Hazard Report No. 23.

Environmental Science and Engineering, Inc. 1993. Explosives/Munitions Manufacturing Areas Operable Unit Phase II Investigation. Preliminary Risk Assessment - Ecological. Crab Orchard National Wildlife Refuge, Marion, Illinois. Prepared for U.S. Army Corps of Engineers.

Ewell, W.S., J.W. Gorsuch, R.O. Kringle, K.A. Robillard and R.C. Spiegel. 1986. Evaluation of the Acute Effects of Chemicals on Seven Aquatic Species. Toxicol. Chem. 5(9):831-840.

Galassi, S., M. Mingazzini, L. Vigano and D. Cesareo. 1988. Approaches to Modeling Toxic Responses of Aquatic Organisms to Aromatic Hydrocarbons. Ecotoxicol. Environ. Saf. 16(2):158-169.

Gerhart, E.H. and R.M. Carlson. 1978. Hepatic Mixed-Function Oxidase Activity in Rainbow Trout Exposed to Several Polycyclic Aromatic Compounds. Environ. Res. 17(2):284-295.

Golder Associates. 1993. Draft Report on Phase I Remedial Investigations of the Miscellaneous Areas Operable Unit. Prepared for U.S. Army Corps of Engineers. 61 pp. plus Appendices.

Halls, L. K. 1978. White-tailed deer. Pages 43-65 in J. L. Schmidt and D. L. Gilbert (Eds.). Big game of North America: ecology and management. Stackpole Books, Harrisburg, Pennsylvania.

Hansen, D.J., S.C. Schimmel and J. Foster. 1974. Aroclor 1254 in Eggs of Sheepshead Minnows: Effect on Fertilization Success and Survival of Embryos and Fry. In: Proceedings of the 27th Annual Conf. Southeastern Assoc. of Game and Fish Commissioners, Hot Springs, AK. pp. 420-426.

Heitmueller, P.T. 1981. Acute Toxicity of 54 Industrial Chemicals to Sheepshead Minnows (Cyprinodon variegatus). Bull. Enviorn. Contam. Toxicol. 27:596-604

Herket, J.R. editor. 1991. Endangered and threatened species of Illinois: status and distribution, Volume 1 - Plants. Illinois Endangered Species Protection Board, Springfield, Illinois. 158 pp.

Herket, J.R. editor. 1992. Endangered and threatened species of Illinois: status and distribution, Volume 2 - Animals. Illinois Endangered Species Protection Board, Springfield, Illinois. 142 pp.

Hite, R.L. and King, M. 1977. Biological Investigation of the Crab Orchard Creek basin, Summer 1975. Illinois EPA, Division of Water Pollution Control. 141 pp.

Howard P.H., R.S. Boethling, W.F. Jarvis, W.M. Meylan and E.M. Michalenko. 1991. Handbook of Environmental Degradation Rates. Lewis Publishers Inc. Chelsea, Michigan. 725 pp.

Illinois Environmental Protection Agency. 1991. Leaking Underground Storage Tank Manual. EPA/LPC/91-203.

King, J. R. 1974. Seasonal allocation of time and energy resources in birds. Pages 4-70 In R. A. Paynter, Jr. ed. Avian energetics. Nuttall Ornithol. Club Publ. 15.

Kociba, R. 1991. Rodent bioassays for assessing chronic toxicity and carcinogenic potential of TCCD. In Biological Basis for Risk Assessment of Dioxins and Related Compounds (ed. Gallo et al.). p13-26. Cold Spring Harbor Laboratory Press 0-87969-235-9/91.

Kohler, C.C., Heidinger, R.C., and Call, T. 1990. Levels of PCBs and trace metals in Crab Orchard Lake sediment, benthos, zooplankton and fish. Prepared for the Illinois Hazardous Waste Research and Information Center, Savoy IL. 130 pp.

Lautier, J. K., T. V. Dailey, and R. D. Brown. 1988. Effect of water restriction on feed intake of white-tailed deer. J. Wildl. Manage. 52:602-606.

Lemke, A.E. 1983. Interlaboratory Comparison of Continuous Flow, Early Life Stage Testing with Flathead Minnows. EPA-600/3-84-005, U.S.EPA, Duluth, MN; U.S. NTIS PB84-129 493:26 P.

Levey, D. J., and W. H. Karasov. 1989. Digestive responses of temperate birds switched to fruit or insect diets. The Auk 106:675-686.

National Ocean and Atmospheric Administration. 1990. The Potential for Biological Effects of sediment-sorbed contaminants Tested in the Natural Status and Trends Program. Tech-Memor. NOS OMA 52. PB91-172288.

Nichols, A. A. 1936. The experimental feeding of deer. Trans. N. Amer. Wildl. Conf. 1:403-410.

O'Brien & Gere Engineers Inc. 1988. Remedial Investigation report, Crab Orchard National Wildlife Refuge. Vol I, Final Report. Submitted to U.S. Fish and Wildlife Service and Sangamo Weston Inc.

Ontario Environment. 1992. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. Water Resources Branch, Ontario Ministry of the Environment.

Oris, J.T. and J.P. Giesy Jr. 1985. The Photoenhanced Toxicity of Anthracene to Juvenile Sunfish. Aquat. Toxicol. 6(2):133-146.

Oris, J.T. and J.P. Giesy Jr. 1987. The Photo-Induced Toxicity of Polycyclic Aromatic Hydrocarbons to Larvae of the Fathead Minnow (Pimephales promelas). Chemosphere 16(7):1395-1404.

Progulske, D. R., and T. S. Baskett. 1958. Mobility of Missouri deer and their harassment by dogs. J. Wildl. Manage. 22:184-192.

Rao, T.S., M.S. Rao and S.B.S.K. Prasad. 1975. Median Tolerance Limits of Some Chemical to the Fresh Water Fish "Cyprinus carpio". Indian J. Environ. Health 17(2):140-146.

Robbins, C. T. 1983. Wildlife feeding and nutrition. Academic Press. New York, N.Y. 343pp.

Sanderson, G. C., 1987. Raccoon. Pages 487-499 in M. Novak et al. (Ed), Wild Furbearer Management and Conservation in North America. Ontario Ministry of Natural Resources.

Sauer, P. R. 1984. Physical characteristics. Pages 73-90 In White-tailed deer ecology and management. Stackpole Books, Harrisburg, PA.

Scott, S.J. and D.H. Hetrick. 1993. The New SESOIL User's Guide. Wisconsin Department of Natural Resources Publ. No. PUBL-SW-200-93.

Schwartz, C.W. and E.R. Schwartz. 1974. The wild mammals of Missouri. University of Missouri Press, Columbia, MO. 341 pp.

Schwartzenbach, R.P. and J. Westall. 1981. Transport of nonpolar organic compounds from surface to groundwater. Laboratory sorption studies. Environ. Sci. Technol. 15:1360-1367.

Schweiger, G. 1957. The Toxic Action of Heavy Metals Salts on Fish and Organisms on Which Fish Feed. Arch. Fischereiwiss 8;54-78 (GER) (ENG ABS)

Smock, L.A., D.L. Stoneburner and J.R. Clark. 1976. The Toxic Effects of Trinitrotoluene (TNT) and its Primary Degradation Products on Two Species of Algae and the Fathead Minnow. Water Res. 10(6):537-543.

Stall, J. B., et al. 1954. Water and land resources of the Crab Orchard Lake Basin. Illinois State Water Survey Bulletin No. 42. 53pp.

Stene, A and S. Lonning. 1984. Effects of 2-Methylnaphthalene on Eggs and Larvae of Six Marine Fish Species. Sarsia 69(3-4):199-203

Suter, G.W. 1993. Ecological Risk Assessment. Lewis Publishers, Chelsea, Michigan. 538 pp.

Thomas, P. and H.W. Wofford. 1984. Elevated Acid-Soluble Thiol Content in Fish Hepatic Tissue: A Response to Pollutants. Mar. Environ. Res. 14 (1-4):486-488.

Travis, C.C and A.D. Arms. 1988. Bioconcentration of organics in beef, milk and vegetation. Env. Sci. Technol. 22:241-274.

Ulaszek, E.F. 1988. The vascular flora of the Devil's Kitchen Lake area, Williamson and Union Counties, Illinois. M.S. Thesis, Southern Illinois University, Carbondale, IL. 98 pp.

Urban, D.L. 1981. Habitat relationships of birds and small animals in second-growth forests. M.A. Thesis, Southern Illinois University, Carbondale, IL. 78pp.

U.S. Environmental Protection Agency. 1979. Water-related Environmental Fate of 129 Priority Pollutants. Vol. 1. Introduction, Technical Background Metals and Inorganics, Pesticides, Polychlorinated Biophenyls, Office of Water Planning and Standards, U.S. EPA Washington, D.C. EPA-440/4-79-029

U.S. Environmental Protection Agency. 1986. Quality Criteria for Water 1986. EPA/44015-86-001.

U.S. Environmental Protection Agency. 1988. Superfund Exposure Assessment Manual. Office of Remedial Response, U.S EPA Washington, D.C. EPA/540/1-88/001. 157 pp.

U.S. Environmental Protection Agency. 1989a. Risk Assessment Guidance for Superfund, Vol II: Environmental Evaluation Manual. EPA/540/1-89/001.

U.S. Environmental Protection Agency. 1989b. Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference. EPA/600/3-89/013.

U.S. Environmental Protection Agency. 1990. Technical Support Document for Water Quality-Based Toxics Control. Office of Water, Washington, D.C. 244 pp.

U.S. Environmental Protection Agency. 1992. Framework for Ecological Risk Assessment. Risk Assessment Forum. Washington, D.C. EPA/630/R-92/001.

U.S. Fish and Wildlife Service. 1992. Crab Orchard National Wildlife Refuge: Annual Narrative Report. Calender Year 1992. 62 pp.

Verschueren, K. 1983. Handbook of Environmental Data on Organic Chemicals. second ed. Van Nostrand Reinhold Company. New York. 1310 pp.

Weston, 1989. Ecological Risk Assessment of Dakota County Resource Recovery Facility. Dakota County, Minnesota. Minnesota Pollution Control Agency.

Wetzel, R. G. 1983. Limnology. Second ed. Saunders College Publ. Philadelphia, Pennsylvania.

Wheelwright, N. T. 1986. The diet of American Robins: an analysis of U.S. Biological Survey records. The Auk 103:710-725.

(08723118.WP1/emp)

TABLE 1
PHASE - I RI ACTIVITIES
MISCELLANEOUS AREAS OPERABLE UNIT

Site Number	Area	Site Name	Phase-I Activity
7	D Area	Southeast Drainage Channel	Sampling
7A	D Area	North Lawn	Sampling
8	D Area	Southwest Drainage Channel	Sampling
9	P Area (North)	Northwest Drainage Channel	Sampling
10	P Area (North)	North Drainage Channel	Sampling
11	P Area	Southeast Drainage Channel	Sampling
11A	P Area (North)	Walkway Structures	Sampling
12	Area 14	Impoundment	Sampling
13	Area 14	Change House	No Investigations
14	Area 14	Solvent Storage Drainage Ditch	Sampling
16	Area 7	Industrial Park	Sampling
18	Area 13	Loading Platform	No Investigations
20	D Area	South Drainage Channel	Sampling
21	Area 7	Southeast Corner Field	Preliminary Site Visit
22A	Old Refuge Shop	Post Treating Facility	Sampling
24[1]	Pepsi Plant	West Drainage Ditch	No Further Action
25[1]	Crab Orchard Creek	Marion Landfill	No Further Action
26[1]	Crab Orchard Creek	Marion Sewage Treatment Plant	No Further Action
27	Crab Orchard Creek	Dredge Area	Preliminary Site Visit
30	Area 13	Munition Control Site	No Investigations
31	None Established	Refuge Control Site	No Invesitgations
34	Crab Orchard Lake	Crab Orchard Lake	No Investigations
35	Area 9	East Waterway	Preliminary Site Visit
36	Area 3 North	Waste-Water Treatment Plant	Sampling

Footnotes:

1 Not located within Refuge boundaries, nor owned by DOI; FFA specifies No Further Action.

(08721459.wp1\djf)

TABLE 2

FEDERAL AND ILLINOIS LISTED THREATENED AND ENDANGERED SPECIES POTENTIALLY OCCURRING IN CRAB ORCHARD NWR

Common Name	Scientific Name	State	Federal
Little Blue Heron	*Florida caerulea*	E	-
Great Egret	*Cadmerodius albus*	E	-
Snowy Egret	*Egretta thula*	E	-
Black-crowned Night Heron	*Nycticorax nycticorax*	E	-
Sharp-shinned Hawk	*Accipiter striatus*	E	-
Cooper's Hawk	*Accipiter cooperii*	E	-
Northern Harrier	*Circus cyaneus*	E	-
Red-shouldered Hawk	*Buteo lineatus*	E	-
Bald Eagle	*Haliaeetus leucocephalus*	E	E
Barn Owl	*Tyto alba*	E	-
Brown Creeper	*Certhia familiaris*	T	-
Bobcat	*Lynx rufus*	T	-
Indiana Bat	*Myotis sodalis*	E	E

E = Endangered
T = Threatened

Sources: USFWS 1988 and 1989 Annual Narrative Reports, Crab Orchard Natural Wildlife Refuge
ESE, 1993

TABLE 3

QUANTITATION LIMITS FOR TARGET COMPOUND LIST VOCs

Volatile Organic Compounds	CAS Number	Method Detection Limits (µg/l)	Soil Quantitation Limits[1] (µg/l)
Benzene	71-43-2	1.0	5
Bromdichloromethane	75-27-4	2.0	5
Bromoform	75-25-2	3.0	5
Bromomethane	74-83-9	2.0	10
Carbon Tetrachloride	56-23-5	2.0	5
Chlorobenzene	108-90-7	3.0	5
Chloroethane	75-00-3	1.0	10
Chloroform	67-66-3	5.0	5
Chloromethane	74-87-3	4.0	10
Dibromochloromethane	124-48-1	1.0	5
1,1-Dichloroethane	75-34-3	2.0	5
1,2-Dichloroethane	107-06-2	2.0	5
1,1-Dichloroethene	75-34-4	2.0	5
1,2-Dichloroethene (Total)	--	---	5
1,2-Dichloropropane	78-87-5	1.0	5
cis-1,3-Dichloropropene	10061-01-5	2.0	5
trans-1,3-Dichloropropene	10061-02-6	1.0	5
Ethyl Benzene	100-41-4	2.0	5
Methylene Chloride[2]	75-09-2	1.0	10
1,1,2,2-Tetrachloroethane	79-34-5	2.0	5
Tetrachloroethene	127-18-4	2.0	5
Toluene[2]	108-88-3	1.0	5
1,1,1-Trichloroethane	71-55-6	3.0	5
1,1,2-Trichloroethane	79-00-5	1.0	5
Trichloroethene	79-01-6	4.0	5
Vinyl Chloride	75-01-4	3.0	10
Acetone[2]	67-64-1	10	10
Carbon Disulfide	75-15-0	2.0	5
2-Butanone[2]	78-93-3	3.0	10
Vinyl Acetate	108-05-4	1.0	10
4-Methyl-2-Pentanone	108-10-1	2.0	10
2-Hexanone	519-78-6	2.0	10
Styrene	100-42-5	2.0	5
Total Xylenes[3]	106-42-3	4	5
2-Chloroethylvinylether	220-75-8	10	10

[1] Quantitation limits for VOCs from Pace Laboratories SOP MN-O-446-B. Quantitation limits listed are based on wet-weight. The quantitation limits calculated by the laboratory on a dry-weight basis, as required by the contract, will be higher.

[2] Common laboratory solvent. Control limits for blanks are five times the method detection limits.

[3] m-Xylene, o-Xylene and p-Xylene are reported as a total of the three (total xylenes).

TABLE 4

QUANTITATION LIMITS FOR TARGET COMPOUND LIST SVOCs

Semivolatile Organic Compounds	CAS Number	Quantitation Limits[1] µg/kg
Phenol	108-95-2	330
bis(2-Chloroethyl)ether	111-44-4	330
2-Chlorophenol	95-57-8	330
1,3-Dichlorobenzene	541-73-1	330
1,4-Dichlorobenzene	106-46-7	330
Benzyl alcohol	100-51-6	330
1,2-Dichlorobenzene	95-50-1	330
2-Methylphenol	95-48-1	330
bis(2-Chloroisopropyl)ether	108-60-1	330
4-Methylphenol	106-44-5	330
N-Nitroso-di-n-propylamine	621-64-7	330
Hexachloroethane	67-72-1	330
Nitrobenzene	98-95-3	330
Isophorone	78-59-1	330
2-Nitrophenol	88-75-5	330
2,4-Dimethylphenol	105-67-9	330
Benzoic acid	65-85-0	1600
bis(2-Chloroethoxy) methane	111-91-1	330
2,4-Dichlorophenol	120-83-2	330
1,2,4-Trichlorobenzene	120-82-1	330
Naphthalene	91-20-3	330
4-Chloroaniline	106-47-8	330
Hexachlorobutadiene	87-68-3	330
4-Chloro-3-methylphenol (para-chloro-meta-cresol)	59-50-7	330
2-Methylnaphthalene	91-57-6	330
Hexachlorocyclopentadiene	77-47-4	330
2,4,6-Trichlorophenol	88-06-2	330
2,4,5-Trichlorophenol	95-95-4	1600
2-Chloronaphthalene	91-58-7	330
2-Nitroaniline	88-74-4	1600
Dimethylphthalate	131-11-3	330
Acenaphthylene	208-96-8	330
2,6-Dinitrotoluene	606-20-2	330
3-Nitroaniline	99-09-8	1600
Acenaphthene	83-32-9	330

TABLE 4

PAGE 2 OF 2

Semivolatile Organic Compounds	CAS Number	Quantitation Limits[1] µg/kg
2,4-Dinitrophenol	51-28-5	1600
4-Nitrophenol	100-02-7	1600
Dibenzofuran	132-64-9	330
2,4-Dinitrotoluene	121-14-2	330
Diethylphthalate	84-66-2	330
4-Chlorophenyl phenyl ether	7005-72-3	330
Fluorene	86-73-7	330
4-Nitroaniline	100-01-6	1600
4,6-Dinitro-2-methylphenol	534-52-1	330
N-Nitrosodiphenylamine	86-30-6	330
4-Bromophenyl phenyl ether	101-55-3	330
Hexachlorobenzene	118-74-1	330
Pentachlorophenol	87-86-5	1600
Phenanthrene	85-01-8	330
Anthracene	120-12-7	330
Di-n-butylphthalate	84-74-2	330
Fluoranthene	206-44-0	330
Pyrene	129-00-0	330
Butyl benzyl phthalate	85-68-7	330
3,3-Dichlorobenzidine	91-94-1	660
Benzo(a)anthracene	56-55-3	330
Chrysene	218-01-9	330
bis(2-Ethylhexyl)phthalate	117-81-7	330
Di-n-Octyphthalate	117-84-0	330
Benzo(b)fluoranthene	205-99-2	330
Benzo(k)fluoranthene	207-08-9	330
Benzo(a)pyrene	50-32-8	330
Indeno(1,2,3-cd)pyrene	193-39-5	330
Dibenzo(a,h)anthracene	52-70-3	330
Benzo(g,h,i)perylene	191-24-2	330
N-Nitrosodimethylamine[2]	65-75-9	330

[1] Quantitation limits for SVOCs from Pace Laboratories SOP MN-O-436-A. Quantitation limits are based on wet weight. The quantitation limits calculated by the laboratory on a dry-weight basis, as required by the contract, will be higher.

[2] This compound was added to the analytical program due to site history.

TABLE 5

QUANTITATION LIMITS FOR TARGET COMPOUND LIST PCBs AND PESTICIDES

Organochlorine and Polychlorinated Biphenyl and Pesticides	CAS Number	Quantitation Limits[1] (μg/kg)
alpha-BHC	319-84-6	1.7
beta-BHC	319-85-7	1.7
delta-BHC	319-86-8	1.7
gamma-BHC (Lindane)	58-89-9	1.7
Heptachlor	76-44-8	1.7
Aldrin	309-00-2	1.7
Heptachlor epoxide	1024-57-3	1.7
Endosulfan I	959-98-8	1.7
Dieldrin	60-57-1	3.3
4,4'-DDE	72-55-9	3.3
Endrin	72-20-8	3.3
Endosulfan II	33213-65-9	3.3
4,4'-DDD	72-54-8	3.3
Endosulfan sulfate	1031-07-8	3.3
4,4'-DDT	50-29-3	3.3
Methoxychlor	72-43-5	17
Endrin aldehyde	7421-36-3	3.3
alpha-Chlordane	5103-71-9	1.7
gamma-Chlordane	5103-74-2	1.7
Toxaphene	8001-35-2	170
Aroclor-1016	12674-11-2	30
Aroclor-1221	11104-28-2	30
Aroclor-1232	11141-16-5	30
Aroclor-1242	53469-21-9	30
Aroclor-1248	12672-29-6	30
Aroclor-1254	11097-69-1	30
Aroclor-1260	11096-82-5	30

1 Quantitation limits for PCB and Pesticide compounds from Pace Laboratories SOP MN-O-447-A. Quantitation limits are based on wet weight. The quantitation limits calculated by the laboratory on a dry-weight basis, as required by the contract, will be higher.

TABLE 6

REPORTING LIMITS FOR EXPLOSIVES

Analyte	CAS Number	Method Reporting Limit[1] ($\mu g/g$)
1,3-Dinitrobenzene	99-65-0	0.249
2,4-Dinitrotoluene	121-14-2	0.251
2,6-Dinitrotoluene	606-20-2	0.500
HMX	2691-41-0	0.499
Nitroglycerin	53-63-0	2.5
PETN	75-11-5	2.50
RDX	121-82-4	0.510
Tetryl	479-45-8	1.27
1,3,5-Trinitrobenzene	99-35-4	0.250
2,4,6-Trinitrotoluene	118-96-7	0.250
2-Nitrotoluene	88-72-2	0.505
3-Nitrotoluene	99-08-1	0.245
4-Nitrotoluene	99-99-0	0.251

[1] Method reporting limit from Pace Laboratories SOP MN-435-B.

HMX: Octahydro-1,3,5,7-tetranitro-s-tetrazoncine
PETN: Pentaerythnitol tetranitrate
RDX: Hexahydro-1,3,5-trinitro-s-triazine
Tetryl: N-methyl-N,2,4,6-tetranitrobenzenamine

TABLE 7

REPORTING LIMIT FOR DIOXINS AND FURANS

Analyte	Reporting Limits[1] (μg/kg)
DIOXINS:	
2,3,7,8-TCDD	0.073
1,2,3,7,8-PeCDD	0.13
1,2,3,4,7,8-HxCDD	0.21
1,2,3,6,7,8-HxCDD	0.11
1,2,3,7,8,9-HxCDD	0.18
1,2,3,4,6,7,8-HpCDD	0.21
OCDD	0.28
FURANS:	
2,3,7,8-TCDF	0.064
1,2,3,7,8-PeCDF	0.1
2,3,4,7,8-PeCDF	0.1
1,2,3,4,7,8-HxCDF	0.12
1,2,3,6,7,8-HxCDF	0.092
2,3,4,6,7,8-HxCDF	0.17
1,2,3,7,8,9-HxCDF	0.22
1,2,3,4,6,7,8,-HpCDF	0.17
1,2,3,4,7,8,9-HpCDF	0.19
OCDF	0.35

[1] Reporting limits from EPA Method 8280

CDFS: Chlorinated dibenzofurans
CDDs: Chlorinated dibenzo-p-dioxins
T: Tetra
Pe: Penta
Hx: Hexa
Hp: Hepta
O: Octa

TABLE 8

DETECTION AND QUANTITATION LIMITS FOR TARGET ANALYTE LIST[1]

Analyte	Method Detection Limit[2] (µg/kg)	Practical Quantitation Limit (mg/kg)
Aluminum	1.4	20
Antimony	2.0	5.0[3]
Arsenic	8.0	10[3]
Barium	0.3	10
Beryllium	0.5	10
Cadmium	0.5	10
Calcium	4.0	40
Chromium	0.6	50
Cobalt	0.7	7.0
Copper	0.7	7.0
Iron	0.7	7.0
Lead	2.0	5[3]
Magnesium	2.0	50
Manganese	0.6	6
Mercury	0.2	0.2
Nickel	1.5	15
Potassium	4.50	450
Selenium	3.0	50
Silver	0.3	3
Sodium	3.0	50
Thallium	10.0	1.0[3]
Vanadium	0.4	4
Zinc	0.2	2
Cyanide	0.1	1

1 The specific SOPs are referenced in the Quality Control Summary Report.

2 The detection limits for samples may be considerably higher depending on the sample matrix.

3 Since the sample required quantitation limit cannot be achieved by using EPA Method 6010, the sample will be analyzed by the appropriate atomic absorption method.

TABLE 9

PRELIMINARY LEVELS OF CONCERN FOR DETECTED ORGANIC COMPOUNDS

Organic Compounds	CCME (mg/kg)	ONTARIO (mg/kg)	NOAA (mg/kg)	LUST (mg/kg)	Preliminary Level of Concern (mg/kg)
VOLATILES					
Acetone	-	-	-	-	>0.37[1]
Ethylbenzene	0.1	-	-	11.7[2]	0.1
Methylene Chloride	-	-	-	-	>0.065[1]
2-Butanone (MEK)	-	-	-	-	>MDL
Toluene	0.1	-	-	11.7[2]	0.1
Xylenes (total)	0.1	-	-	11.7[2]	0.1
SEMIVOLATILES					
Acenaphthene	-	-	0.15	8.4	0.15
Anthracene	-	-	0.085	42.0	0.085
Benzo(a)anthracene	0.1	-	0.23	0.0026	0.0026
Benzo(a)pyrene	0.1	-	0.40	0.0046	0.0046
Benzo(b)fluoranthene	0.1	-	-	0.0036	0.0036
Bis(2-ethylhexyl)phthalate (DEHP)	30	-	-	-	30
Chrysene	-	-	0.4	0.03	0.03
Di-n-butylphthalate	30	-	-	-	30
Dibenzofuran	-	-	-	-	>MDL
Fluoranthene	-	-	0.6	5.6	0.6
Fluorene	-	-	0.035	5.6	0.035
2-Methylnaphthalene	-	-	0.065	-	0.065
Naphthalene	0.1	-	0.34	0.025	0.025
Pentachlorophenol	0.05	-	-	-	0.05
Phenanthrene	0.1	-	0.225	4.2[3]	0.1
Pyrene	0.1	-	0.35	4.2	0.1

TABLE 9

PAGE 2 OF 2

Organic Compounds	CCME (mg/kg)	ONTARIO (mg/kg)	NOAA (mg/kg)	LUST (mg/kg)	Preliminary Level of Concern (mg/kg)
EXPLOSIVES					
2,4,6-Trinitrotoluene (TNT)	-	-	-	-	>MDL
ORGANOCHLORINE PESTICIDES AND PCBs					
Aldrin	-	0.002	-	-	0.002
4,4'-DDD	-	0.008	0.002	-	0.002
4,4'-DDE	-	0.005	0.002	-	0.002
4,4'-DDT	-	0.007	0.003	-	0.003
Heptachlor Epoxide	-	0.005	-	-	0.005
Aroclor-1248	0.5	0.03	0.05[4]	-	0.03
Aroclor-1254	0.5	0.06	0.05[4]	-	0.05
Aroclor-1260	0.5	0.005	0.05[4]	-	0.005
Dioxins/Furans	0.00001[5]	-	-		0.00001

CCME - CCME (1991) - most sensitive remediation criteria
ONTARIO - Ontario Envionment (1992) - lowest effect level
NOAA - NOAA (1990) - based on ER-L, a concentraation at the low end of the range in which effects have been observed
LUST - IEPA (1991) - soil cleanup objectives for Type A soil
MDL - method detection limit

[1] Upper bound of range reported for laboratory contaminants, Quality Control Summary Report, Phase I RI of the Misc AOU, 1993
[2] Total BETX - sum of benzene, ethylbenzene, toluene and xylene concentrations.
[3] Other Non-carcinogenic PNAs (Total) - sum of acenaphthylene, benzo(g,h,i)perylene, phenanthrene
[4] Total PCBs
[5] Expressed as 2,3,7,8-TCDD equivalents using NATO International Toxicity Equivalency Factors (Appendix III)

TABLE 10

PRELIMINARY LEVELS OF CONCERN FOR DETECTED INORGANIC ANALYTES

Inorganic Analyte	CCME (mg/kg)	ONTARIO (mg/kg)	NOAA (mg/kg)	Background Soil[1]			Ecological Preliminary Level of Concern (mg/kg)
				MEAN (mg/kg)	SD (mg/kg)	Upper 95% CI (mg/kg)	
Aluminum	-	-	-	13590	4729	23048	23048
Antimony	20	-	2.0	0.97	0.52	2.01	2.01
Arsenic	20	6	33	5.7	3.1	11.8	11.8
Barium	500	-	-	105.9	27.1	160.0	500
Beryllium	4	-	-	0.64	0.11	0.86	4
Cadmium	3	0.6	5	0.25	0.25	0.75	0.75
Chromium	250	26	80	42.9	7.2	57.4	57.4
Cobalt	40	50	-	9.7	3.7	17.0	40
Copper	100	16	70	12.8	4.0	20.9	20.9
Iron	-	-	-	19913	5877	31666	31666
Lead	375	31	35	14.4	3.4	21.3	31
Manganese	-	460	-	495	292	1080	1080
Mercury	0.8	0.2	0.15	0.05	0.00	0.06	0.15
Nickel	100	16	30	15.3	5.6	26.6	26.6
Selenium	2	-	-	0.35	0.30	0.95	2
Silver	20	0.5	1.0	0.42	0.18	0.77	0.77
Thallium	1	-	-	0.24	0.13	0.50	1
Vanadium	200	-	-	35.4	15.5	66.3	200
Zinc	500	120	120	50.8	34.6	120.0	120
Total Cyanide	5	0.1	-	-	-	-	0.1

CCME - CCME (1991) - most sensitive remediation criteria
ONTARIO - Ontario Envionment (1992) - lowest effect level
NOAA - NOAA (1990) - based on ER-L, a concentration at the low end of the range in which effects have been observed
LUST - IEPA (1991) - soil cleanup objectives for Type A soil

[1] Phase 1 RI of the Misc AOU, Appendix B

TABLE 11

CONSTITUENTS DETECTED AT LEVELS ABOVE PRELIMINARY LEVELS OF CONCERN

Site(s)	Constituents
7	none
7A	none
8	MEK
9	Silver
10	MEK, Phenanthrene, Fluoranthene, Pyrene, Benzo(a)anthracene, Benzo(b)fluoranthene, Cadmium, Silver
11	Arsenic, Silver
11A	Acetone, MEK, 2,4,6-TNT, Silver
12	Acetone, MEK, Phenanthrene, Pyrene, Silver
14	Methylene Chloride, Ethylbenzene, Xylenes, MEK, Cyanide, Lead, Mercury, Cadmium, Chromium, Copper, Manganese, Silver
16	PCBs, Cadmium, Copper, Silver
20	Lead, Silver
22A	MEK, Pentachlorophenol, Phenanthrene, Anthracene, Pyrene, Benzo(a)anthracene, Chrysene, Benzo(b)fluoranthene, Benzo(a)pyrene, DDD, DDE, DDT, Dioxins/Furans, Mercury, Cadmium, Manganese, Silver
36 - Dove Creek	Aldrin, PCBs, Cadmium, Copper, Lead, Mercury, Silver, Zinc
36 - West Pond	Cadmium, Silver
36 - East Pond	Methylene Chloride, Acetone, MEK, Naphthalene, 2-Methylnaphthalene, Acenapthene, Dibenzofuran, Fluorene, Phenanthrene, Anthracene, Fluoranthrene, Pyrene, Benzo(a)anthracene, Bis(2-ethylhexyl)phthalate, Chrysene, Benzo(b)fluoranthene, Benzo(a)pyrene, Aldrin, PCB, Lead, Mercury, Cadmium, Chromium, Copper, Manganese, Nickel, Antimony, Silver, Zinc
36 - Primary Lagoon	Acetone, PCBs

TABLE 12

CHEMICAL CHARACTERIZATION - ORGANICS

Compound	Kow log	Solubility mg/L @25°C	Vapor Pressure mm/Hg	MW	BCF[1] (animals) log	BCF[2] (plants) log
VOLATILES						
Acetone	-0.24	miscible	2.30E+02	58.1	-0.41	1.73
2-Butanone (MEK)	0.29	2.23E+05	95.3E+00	72.1	-0.01	1.42
Ethylbenzene	3.15	1.69E+02	9.60E+00	106.17	1.18	-0.23
Methylene Chloride	1.25	1.30E+04	4.33E+02	84.9	0.72	0.87
o-Xylene	3.12	1.78E+02	6.61E+00	106.18	2.15	-0.22
m-Xylene	3.20	1.61E+02	8.30E+00	106.17	1.18	-0.26
p-Xylene	3.15	1.62E+02	8.90E+00	90.08	1.18	-0.23
SEMI-VOLATILES						
Acenaphthene	3.92	3.57E+00	2.50E-03	154.21	2.59	-0.68
Anthracene	4.45	4.34E-02	2.67E-06	178.23	3.13	-0.98
Benzo(a)anthracene	5.66	9.40E-03	1.05E-07	228.29	2.54	-1.68
Benzo(b)fluoranthene	6.12	1.50E-03	5.00E-07	252.32	4.38	-1.95
Benzo(a)pyrene	5.97	1.62E-03	5.49E-09	252.32	2.96	-1.25
Bis(2-ethylhexyl)phthalate	5.11	3.40E-01	6.78E-08	390.50	0.69-4.13	-1.37
Chrysene	5.66	2.00E-03	6.23E-09	228.29	4.07	-1.68
Dibenzofuran	4.12	3.10E+00	1.80E-04	168.20	3.13	-0.79
Fluoranthene	4.95	2.06E-01	1.23E-08	202.26	3.60	-1.27
Fluorene	4.18	1.98E+00	6.33E-04	166.22	3.11	-0.83
2-Methylnaphthalene	3.86	2.40E+01	5.50E-02	142	1.99	-0.64
Naphthalene	3.30	3.10E+01	8.50E-02	128.18	2.63	-0.32
Pentachlorophenol	5.12	1.95E+03	3.17E-05	266.34	2.89	-1.37
Phenanthrene	4.46	1.15E+00	1.12E-04	178.23	3.25	-0.99
Pyrene	4.88	1.35E+00	4.59E-06	202.26	3.43	-1.23

TABLE 12

PAGE 2 OF 2

Compound	Kow log	Solubility mg/L @25°C	Vapor Pressure mm/Hg	MW	BCF[1] (animals) log	BCF[2] (plants) log
PESTICIDES, PCBs AND DIOXINS/FURANS						
Aldrin	5.52	1.70E-02	6.01E-06	364.90	3.50	-1.67
Aroclor-1248	6.47[4]	0.0035-0.906	3.75E-01	223.1-498.7	5.1[5]	-2.15
Aroclor-1254	6.47[3]	0.0035-0.906	3.75E-01	223.1-498.7	5.5[5]	-1.77
Aroclor-1260	6.47[4]	0.0035-0.906	3.75E-01	223.1-498.7	5.4[5]	-2.15
DDD	6.02	9.00E-02	6.70E-07	320.0	4.9	-1.89
DDE	5.69	1.20E-01	6.00E-06	318.0	4.91	-0.98
DDT	6.36	2.50E-02	1.60E-07	354.5	4.97	-1.80
2,3,7,8-TCDD	6.15[3]	-	-	-	5.1[6]	-1.87
EXPLOSIVES						
2,4,6-Trinitrotoluene	1.60	1.24E+02	2.02E-06	227.13	1.61	0.66

Values obtained from USEPA's Environmental Fate Database (ENVIROFATE) unless otherwise noted.

[1] Animal BCF based on concentration in tissue vs. water

[2] Vegetation bioconcentration factor (dry wt. basis; uptake from soil), based on the regression equation given in Travis and Arms (1988); experimentally measured BCFs given for benzo(a)pyrene, TCDD, aldrin and Aroclor-1254, DDD, DDE, and DDT

[3] Travis and Arms (1988)

[4] Assumed to be the same as for Aroclor-1254.

[5] Based on maximum bioaccumulation factor for fathead minnows reported in Verschueren (1983)

[6] Cook et al. (1991)

TABLE 13

HALF LIVES

Compound	Half-Lives (days)			
	Soil	Air	Surface Water	Ground Water
VOLATILES				
Acetone	1-7	12-116	1-7	2-14
2-Butanone (MEK)	1-7	3-27	1-7	2-14
Ethylbenzene	3-10	0.357-3.57	3-10	6-228
Methylene Chloride	7-28	61-613	7-28	14-56
o-Xylene	7-28	0.183-1.8	7-28	14-360
m-Xylene	7-28	0.108-1.1	7-28	14-56
p-Xylene	7-28	0.175-1.7	7-28	14-56
SEMI-VOLATILES				
Acenaphthene	12.3-102	0.037-0.366	0.125-12.5	24.6-204
Anthracene	50-460	0.024-0.071	0.024-0.071	100-920
Benzo(a)anthracene	102-680	0.125-0.042	0.125-0.042	204-1360
Benzo(b)fluoranthene	360-610	0.06-0.596	0.363-30	720-1220
Benzo(a)pyrene	57-530	0.015-0.046	0.015-0.046	114-1060
Bis(2-ethylhexyl)phthalate	5-23	0.121-1.208	5-23	10-389
Chrysene	371-1000	0.033-0.334	0.183-0.542	742-2000
Dibenzofuran	7-28	0.079-0.792	7-28	8.5-35
Fluoranthene	140-440	0.084-0.842	0.875-2.6	280-880
Fluorene	32-60	0.284-2.8	32-60	64-120
2-Methylnapthalene	-	-	-	-
Naphthalene	16.6-48	0.123-1.233	0.5-20	1-258
Pentachlorophenol	23-178	5.8-58	0.042-4.6	46-1520
Phenanthrene	16-200	0.084-0.837	0.125-1.042	32-400
Pyrene	210-1900	0.028-0.085	0.028-0.085	420-3800

TABLE 13

PAGE 2 OF 2

Compound	Half-Lives (days)			
	Soil	Air	Surface Water	Ground Water
PESTICIDES, PCBs AND DIOXINS/FURANS				
Aldrin	21-591.67	0.038-0.379	21-591.67	1-1183.33
Aroclor-1248	-	-	-	-
Aroclor-1254	-	-	-	-
Aroclor-1260	-	-	-	-
DDD	730-5694	7.4	730-5694	70-11425
DDE	730-5694	7.4	6.1	16-11425
DDT	730-5694	7.4	7-350	16-11425
2,3,7,8-TCDD	418-590	0.929-9.3	418-590	836-1180
EXPLOSIVES				
2,4,6-Trinitrotoluene	28-180	0.154-0.471	0.007-0.053	28-360

Values given in Howard et al. (1991)

TABLE 14

CHEMICAL CHARACTERIZATION - INORGANICS

Compound	k_d[1]	BCF[2] (animals) log	BCF[2] (plants) log
Antimony	1	2.5	2.0
Arsenic	0.1	2.5	1.7
Cadmium	1	3.9[3]	2.7[4]
Chromium	1	2.3	2.7
Copper	1	2.3	3.0
Cyanide	0.1	1.0[5]	1.0[5]
Lead	1	3.8	3.3
Manganese	1	2.0[6]	5.0[6]
Mercury	1	3.5	3.5[7]
Nickel	1	2.0	2.0
Silver	1	3.5	2.3
Zinc	1	3.3	3.6

1 Ratio of particulate to dissolved form; used to estimate water column concentrations from sediment data. Under the environmental conditions present at these sites, these compounds (except for arsenic and cyanide) would exist predominantly in particulate forms; therefore, it was conservatively estimated that they would partition equally between soils and water. For arsenic and cyanide, it was assumed that most (90%) would be dissolved.

2 Most conservative values from USEPA's Oil and Hazardous Materials/Technical Assistance Data System (OHMTADS) unless otherwise stated; BCFs based on concentrations in tissue vs water.

3 Eisler (1985)

4 Assumed to be intermediate between Sb and Pb (Baudo et al. 1990)

5 Cyanide is not accumulated or biomagnified in food webs (Eisler 1991)

6 CCREM (1987)

7 Assumed to be the same as for animals.

TABLE 15

COMPOUNDS OF CONCERN FOR SITE 22A

Compound	Maximum Sample Concentration (mg/kg)	Preliminary Level of Concern (mg/kg)
VOLATILES		
2-Butanone (MEK)	0.005	>MDL
SEMI-VOLATILES		
Anthracene	0.2	0.085
Benzo(a)anthracene	0.55	0.0026
Benzo(b)fluoranthene	0.72	0.0036
Benzo(a)pyrene	0.39	0.0046
Chrysene	0.63	0.03
Pentachlorophenol	3.2	0.05
Phenanthrene	0.21	0.1
Pyrene	0.59	0.1
PESTICIDES, PCBs AND DIOXINS/FURANS		
DDD	0.0121	0.002
DDE	0.027	0.002
DDT	0.036	0.003
2,3,7,8-TCDD[1]	0.0095	0.00001
INORGANICS		
Cadmium	1.04	0.75
Manganese	1600	1080
Mercury	0.26	0.15
Silver	1.6	0.77

[1] Calculated using NATO International Toxicity Equivalents

TABLE 16

COMPOUNDS OF CONCERN FOR SITE 36 - EAST POND

Compound	Maximum Sample Concentration (mg/kg)	Preliminary Level of Concern (mg/kg)
VOLATILES		
Acetone	0.88	0.37
2-Butanone (MEK)	0.161	>MDL
Methylene Chloride	0.8	0.065
SEMI-VOLATILES		
Acenaphthene	28.0	0.15
Anthracene	9.40	0.085
Benzo(a)anthracene	3.90	0.0026
Benzo(b)fluoranthene	3.90	0.0036
Benzo(a)pyrene	1.44	0.0046
Bis(2-ethylhexyl)phthalate	1.22	30
Chrysene	2.61	0.03
Dibenzofuran	19.7	>MDL
Fluoranthene	24.2	0.6
Fluorene	44.0	0.035
2-Methylnapthalene	18.9	0.065
Naphthalene	6.1	0.025
Phenanthrene	50.0	0.1
Pyrene	13.9	0.1
PESTICIDES, PCBs AND DIOXINS/FURANS		
Aldrin	3.30	0.002
Aroclor-1248	42.0	0.03
Aroclor-1254	80.0	0.05
Aroclor-1260	78.0	0.005

TABLE 16

Compound	Maximum Sample Concentration (mg/kg)	Preliminary Level of Concern (mg/kg)
INORGANICS		
Antimony	39.0	2.01
Cadmium	27.0	0.75
Chromium	200	57.4
Copper	158	20.9
Lead	500.0	31
Manganese	1300	1080
Mercury	3.0	0.15
Nickel	36	26.6
Silver	108	0.77
Zinc	800	120

TABLE 17

CONCEPTUAL EXPOSURE MODEL FOR CRAB ORCHARD MISC AOU

Site/Affected Media	Primary Release Mechanisms	Primary Transport Media	Primary Exposure Points	Primary Exposure Routes	Potential Receptors (most sensitive)
Site 8/Sediment	Groundwater Surface runoff Volatilization	Water Air	At source; offsite streams	Dermal absorption Inhalation	Aquatic life Terrestrial predator (aquatic prey)
Site 9/Sediment	Groundwater Surface runoff	Water Food	At source; onsite and offsite streams	Dermal absorption Incidental ingestion Consumption of plant and animal tissue	Aquatic life Terrestrial predator (aquatic prey)
Site 10/Sediment	Groundwater Surface runoff Volatilization	Water Food Air	At source; onsite and offsite streams	Incidental ingestion Dermal absorption Consumption of plant and animal tissue Inhalation	Aquatic life Terrestrial predator (aquatic prey)
Site 11/Sediment	Groundwater Surface runoff	Water Food	At source; offsite streams	Dermal absorption Incidental ingestion Consumption of plant and animal tissue	Aquatic life Terrestrial predator (aquatic prey)
Site 11A/Soils	Groundwater Surface runoff Volatilization	Water Food Air	At source; offsite streams	Incidental ingestion Dermal absorption Inhalation	Aquatic life Terrestrial herbivore Terrestrial predator (terrestrial prey)

TABLE 17

Site/Affected Media	Primary Release Mechanisms	Primary Transport Media	Primary Exposure Points	Primary Exposure Routes	Potential Receptors (most sensitive)
Site 12/Soils	Groundwater Surface runoff Volatilization	Water Air Food	At source; offsite streams	Incidental ingestion Dermal absorption Inhalation Consumption of plant and animal tissue	Aquatic life Terrestrial herbivore Terrestrial predator (terrestrial prey)
Site 14/Soils	Groundwater Surface runoff Volatilization	Water Air	At source, offsite streams	Incidental ingestion Dermal absorption Inhalation Consumption of plant and animal tissue	Aquatic life Terrestrial herbivore Terrestrial predator (terrestrial prey)
Site 16/Sediment	Groundwater Surface runoff Volatilization	Water Food	At source; offsite streams	Incidental ingestion Dermal absorption Consumption of plant and animal tissue	Aquatic life Terrestrial herbivore Terrestrial predator (terrestrial prey)
Site 20/Soils	Groundwater Surface runoff	Water Food	At source; offsite streams	Incidental ingestion Dermal absorption Consumption of plant and animal tissue	Aquatic life Terrestrial herbivore Terrestrial predator (terrestrial prey)

TABLE 17

PAGE 3 OF 3

Site/Affected Media	Primary Release Mechanisms	Primary Transport Media	Primary Exposure Points	Primary Exposure Routes	Potential Receptors (most sensitive)
Site 22A/Soils	Suface runoff Groundwater Volatilization	Water Air Food	At source; offsite streams	Incidental ingestion Dermal absorption Consumption of plant and animal tissue Inhalation	Aquatic life Terrestrial herbivore Terrestrial predator (terrestrial prey)
Site 36-Sediment/ Sludge	Groundwater Surface runoff Volatilization	Water Food Air	At source; offsite streams	Incidental ingestion Dermal absorption Consumption of plant and animal tissue Inhalation	Aquatic life Terrestrial herbivore Terrestrial predator (aquatic prey)

TABLE 18

SUMMARY OF TARGET SPECIES INVESTIGATED AT EACH SITE

Site	Aquatic Organisms	White-Tailed Deer	Raccoons	American Robin
8	√	√	√	
9	√	√	√	
10	√	√	√	
11	√	√	√	
11A	√	√		√
12	√	√		√
14	√	√		√
16	√	√		√
20	√	√		√
22A	√	√		√
36 - Dove Creek	√	√	√	
36 - West Pond	√	√	√	
36 - East Pond	√	√	√	
36 - Lagoon	√	√	√	

TABLE 19

DERIVATION OF CRITICAL TOXICITY VALUES FOR AQUATIC LIFE

Compound	USEPA		Toxicity Tests				CTV µg/L
	Acute µg/L	Chronic µg/L	Acute µg/L	Chronic µg/L	Organism	Reference	
VOLATILES							
Acetone	-	-	>100,000	-	fathead minnow	Ewell et al. (1986)	10,000
2-Butanone (MEK)	-	-	400,000	-	sheepshead minnow	Heitmueller (1981)	40,000
Ethylbenzene	32,000*	-	4,200	-	rainbow trout	Galassi et al. (1988)	420
Methylene Chloride	-	-	-	82,500	fathead minnow	Dill et al. (1987)	16,500
o-Xylene	-	-	7,600	-	rainbow trout	Galassi et al. (1988)	760
m-Xylene	-	-	3,530	-	leopard frog	Black et al. (1982)	353
p-Xylene	-	-	2,600	-	rainbow trout	Galassi et al. (1988)	260
SEMI-VOLATILES							
Acenaphthene	1,700*	520*	-	33	fathead minnow	Lemke (1983)	6.6
Anthracene	-	-	2.8	-	bluegill	Oris and Giesy (1985)	0.28
Benzo(a)anthracene	-	-	1.8	-	fathead minnow	Oris and Giesy (1987)	0.18
Benzo(b)fluoranthene	-	-	-	-	-	-	0.18[1]
Benzo(a)pyrene	-	-	-	0.40	rainbow trout	Carlson et al. (1979)	0.08
Bis(2-ethylhexyl)phthalate	940*3	30*3	-	-	-	-	30
Chrysene	-	-	-	30	rainbow trout	Carlson et al. (1979)	6
Dibenzofuran	-	-	1,780	-	fathead minnow		17.8

TABLE 19

PAGE 2 OF 4

Compound	USEPA		Toxicity Tests				CTV µg/L
	Acute µg/L	Chronic µg/L	Acute µg/L	Chronic µg/L	Organism	Reference	
Fluoranthene	3,980[*]	-	90	-	leopard frog		0.9
Fluorene	-	-		100	striped mullet	Thomas and Wofford (1984)	20
2-Methylnaphthalene	-	-	-	300	atlantic cod	Stene and Lonning (1984)	60
Naphthalene	2,300[*]	620[*]	110	-	rainbow trout	Black et al. (1983)	11
Pentachlorophenol	20	13	-	-	-	-	13
Phenanthrene	-	-	30	-	rainbow trout	Gerhart and Carlson (1978)	3
Pyrene	-	-	25.6	-	fathead minnow	Oris and Giesy (1987)	2.56
PESTICIDES, PCBs AND DIOXINS/FURANS							
Aldrin	3.0	-	3.7	-	common carp	Rao et al. (1975)	0.37
Aroclor-1248	2.0[3]	0.014[3]	-	0.10	fathead minnow	Defoe et al. (1978)	0.014
Aroclor-1254	2.0[3]	0.014[3]	-	0.09	sheepshead minnow	Hanson et al. (1974)	0.014
Aroclor-1260	2.0[3]	0.014[3]	-	0.10	fathead minnow	Defoe et al. (1978)	0.014
DDD	-	-	2.5	-	striped bass	Earnest (1974)	0.025
DDE	1,050	-	-	-	-	-	105
DDT	1.1	0.001	-	-	-	-	0.001
2,3,7,8-TCDD	0.01[*]	0.00001[*]	-	-	-	-	0.00001

TABLE 19

Compound	USEPA		Toxicity Tests				CTV µg/L
	Acute µg/L	Chronic µg/L	Acute µg/L	Chronic µg/L	Organism	Reference	
EXPLOSIVES							
2,4,6-Trinitrotoluene	-	-	-	460	fathead minnow	Smock et al. (1976)	92
INORGANICS							
Antimony	9,000[*]	1,600[*]	-	-	-	-	1600
Arsenic	850[*4]	48[*4]	-	-	-	-	48
Cadmium	3.9[5]	1.1[5]	-	-	-	-	1.1
Chromium	16[6]	11[6]	-	-	-	-	210
Copper	18[5]	12[5]	-	-	-	-	12
Cyanide	22	5.2	-	-	-	-	5.2
Lead	82[5]	3.2[5]	-	-	-	-	3.2
Manganese	-	-	75,000	-	rainbow trout	Schweiger (1957)	7,500
Mercury	2.4	0.012	-	-	-	-	0.012
Nickel	1,400[5]	160[5]	-	-	-	-	160

TABLE 19

Compound	USEPA		Toxicity Tests				CTV µg/L
	Acute µg/L	Chronic µg/L	Acute µg/L	Chronic µg/L	Organism	Reference	
Silver	4.1[5]	0.12	-	-	-	-	0.12
Zinc	120*	110*	-	-	-	-	110

USEPA - USEPA (1986)
Toxicity test values are lowest reported for freshwater fish or amphibians (unless otherwise noted)
* Insufficient data to develop criteria, value presented is the lowest observed effect level
[1] Assumed to be the same as for Benzo(a)anthracene
[2] Phthalate esters
[3] PCBs
[4] Arsenic (V)
[5] Hardness-dependent (100 mg/L used)
[6] Chromium (VI)

TABLE 20

DERIVATION OF CRITICAL TOXICITY VALUES - WILDLIFE (INGESTION)

Compound	USFWS[1] mg/kg	Toxicity Tests[2]				CTV mg/kg
		Acute mg/kg	Chronic mg/kg	Test	Organism	
VOLATILES						
Acetone	-	-	2857	TDlo	Human	114
2-Butanone (MEK)	-	2737	-	LD50	Rat	55
Ethylbenzene	-	3500	-	LD50	Rat	70
Methylene Chloride	-	357	-	LDlo	Human	7.1
o-Xylene	-	5000	-	LDlo	Rat	100
m-Xylene	-	5000	-	LD50	Rat	100
p-Xylene	-	5000	-	LD50	Rat	100
SEMI-VOLATILES						
Acenaphthene	-	600	-	LD50	Rat	12
Anthracene	-	17000	-	LD50	Mouse	340
Benzo(a)anthracene	-	200	-	LD50	Rat	4
Benzo(b)fluoranthene	-	-	5	TDlo	Rat	0.2
Benzo(a)pyrene	-	-	15	TDlo	Rat	0.6
Bis(2-ethylhexyl)phthalate	-	-	143	TDlo	Human	5.7
Chrysene	-	320	-	LD50	Mouse	6.4
Dibenzofuran[3]	-	-	50	NOAEL	Rat	2.0
Fluoranthene	-	2000	-	LD50	Rat	40
Fluorene	-	2000	-	LD50	Mouse	40
2-Methylnapthalene	-	1630	-	LD50	Rat	32.6
Naphthalene	-	400	-	LDlo	Dog	8
Pentachlorophenol	0.05	27	-	LD50	Rat	0.05
Phenanthrene	-	700	-	LD50	Mouse	14
Pyrene	-	800	-	LD50	Mouse	16

TABLE 20

PAGE 2 OF 3

Compound	USFWS[1] mg/kg	Toxicity Tests[2]				CTV mg/kg
		Acute mg/kg	Chronic mg/kg	Test	Organism	
PESTICIDES, PCBs, AND DIOXINS/FURANS						
Aldrin	-	-	14	TDlo	Human	0.56
Aroclor-1248	1.5	11000	-	LD50	Rat	1.5
Aroclor-1254	1.5	1010	-	LD50	Rat	1.5
Aroclor-1260	1.5	1315	-	LD50	Rat	1.5
DDD	-	113	-	LD50	Rat	2.3
DDE	-	700	-	LD50	Mouse	14
DDT	-	32	-	LD50	Mouse	0.6
2,3,7,8-TCDD	-	-	-	NOAEL	Rat	0.00001[4]
EXPLOSIVES						
2,4,6-Trinitrotoluene	-	500	-	LDlo	Rabbit	10
INORGANICS						
Antimony	-	7000	-	LD50	Rat	140
Arsenic	2.0	-	-	-	-	2
Cadmium	0.1[5]	70	-	LDlo	Rabbit	0.1
Chromium	0.1[6]	-	2160	TDlo	Rat	0.1
Copper	-	-	0.12	TDlo	Human	0.0048
Cyanide	90	3.0	-	LD50	Mouse	0.06
Lead	0.2	160	-	LDlo	Pigeon	0.2
Manganese	-	9000	-	LD50	Rat	180
Mercury	0.05	-	129	TDlo	Human	0.05
Nickel	-	-	5	LDlo	Guinea Pig	0.2

TABLE 20

PAGE 3 OF 3

Compound	USFWS[1] mg/kg	Toxicity Tests[2]				CTV mg/kg
		Acute mg/kg	Chronic mg/kg	Test	Organism	
Silver	-	-	11	TDlo	Mouse	0.44
Zinc	178	-	-	-	-	178

NOAEL - No observable adverse effect level; LD50 - lethal dose for 50% of test population; LDlo - lethal dose for any members of test population; TDlo - lowest dose reported to produce any toxic effect.

1 US Fish and Wildlife Service Contaminant Hazard Review Reports; lowest proposed criteria for wildlife, unless noted otherwise.
2 Most conservative value from US National Institute of Occupational Safety and Health's RTECS database.
3 Based on biphenyl which is structurally similar
4 Kociba 1991
5 Insufficient data for wildlife, based on NOAEL (Eisler 1985)
6 Insufficient data for wildlife, based on human health protection (Eisler 1986)

TABLE 21

DERIVATION OF CRITICAL TOXICITY - WILDLIFE (INHALATION)

Compound	Toxicity Tests[1]				CTV mg/m³
	ppm	mg/m³	Test	Organism	
Acetone	17957	43400	TClo	Cat	868
2-Butanone (MEK)	100	300	TClo	Human	6.0
Ethylbenzene	100	441.6	TClo	Hamster	8.8
Methylene Chloride	500	1766	TClo	Hamster	35.3
o-Xylene	6125	27048	LClo	Hamster	541
m-Xylene	4550	17048	LC50	Rat	341
p-Xylene	2010	8876	LClo	Mouse	178

Note:
conversion of ppm to mg/m³ based on ideal gas law at 20° C;
LC50 - lethal concentrations for 50% of test population;
LClo - lethal concentrations for any member of test population;
TClo - lowest concentrations reported to produce any toxic effect.

[1] Most conservative value from US National Institute of Occupational Safety and Health's RTECS database.

TABLE 22

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FROM BACKGROUND SOIL SAMPLES

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{sum}
White-Tailed Deer				
Antimony	3.83E-06	9.57E-06	4.31E-02	4.31E-02
Arsenic	1.57E-03	3.93E-01	8.87E+01	8.91E+01
Cadmium	2.00E-03	5.00E-03	1.13E+02	1.13E+02
Chromium	1.53E-01	3.83E-01	8.63E+03	8.63E+03
Copper	1.16E+00	2.90E+00	1.31E+05	1.31E+05
Lead	2.84E-02	7.10E-02	6.37E+03	6.38E+03
Manganese	1.60E-03	4.00E-03	1.80E+04	1.80E+04
Mercury	3.20E-04	8.00E-04	1.14E+02	1.14E+02
Nickel	3.55E-02	8.87E-02	3.99E+02	3.99E+02
Silver	4.67E-04	1.17E-03	1.05E+01	1.05E+01
Zinc	1.80E-04	4.49E-04	8.05E+01	8.05E+01
Robins				
Antimony	3.59E-04	1.44E-05	3.98E+00	3.98E-01
Arsenic	1.48E-01	5.90E-02	1.64E+04	1.64E+03
Cadmium	1.87E-01	7.50E-03	4.17E+04	4.17E+04
Chromium	1.44E+01	5.74E-01	1.00E+05	1.00E+05
Copper	1.09E+02	4.35E+00	7.60E+05	7.61E+05
Lead	2.66E+00	1.07E-01	5.88E+05	5.88E+05
Manganese	1.50E-01	6.00E-03	5.25E+02	5.25E+02
Mercury	3.00E-02	1.20E-03	3.32E+03	3.32E+03
Nickel	3.33E+00	1.33E-01	1.16E+04	1.16E+04
Silver	4.38E-02	1.75E-03	4.84E+03	4.84E+03
Zinc	1.69E-02	6.74E-04	1.18E+03	1.18E+03

TABLE 22

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{sum}
Raccoons				
Antimony	1.20E-05	7.18E-06	7.57E-02	7.57E-02
Arsenic	4.92E-03	2.95E-01	3.11E+02	3.11E+02
Cadmium	6.25E-03	3.75E-03	9.93E+01	9.93E+01
Chromium	4.78E-01	2.87E-01	1.91E+03	1.91E+03
Copper	3.63E+00	2.18E+00	1.45E+04	1.45E+04
Lead	8.88E-02	5.33E-02	1.12E+04	1.12E+04
Manganese	5.00E-03	3.00E-03	1.00E+01	1.00E+01
Mercury	1.00E-03	6.00E-04	6.32E+01	6.32E+01
Nickel	1.11E-01	6.65E-02	2.22E+02	2.22E+02
Silver	1.46E-03	8.75E-04	9.22E+01	9.22E+01
Zinc	5.62E-04	3.37E-04	2.24E+01	2.24E+01
Aquatic Life				
Antimony	-	-	-	1.26E-02
Arsenic	-	-	-	2.46E+02
Cadmium	-	-	-	6.82E+00
Chromium	-	-	-	2.73E+00
Copper	-	-	-	1.74E+01
Lead	-	-	-	6.66E+01
Manganese	-	-	-	1.44E+00
Mercury	-	-	-	5.00E+01
Nickel	-	-	-	1.66E+00
Silver	-	-	-	6.42E+01
Zinc	-	-	-	1.09E+01

ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.

TABLE 23

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FOR CONSTITUENTS OF CONCERN - SITE 8

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
White-Tailed Deer					
2-Butanone (MEK)	2.91E-07	2.43E-04	8.61E-04	5.53E-01	5.54E-01
Raccoons					
2-Butanone (MEK)	9.09E-07	1.82E-04	5.93E-04	5.53E-01	5.54E-01
Aquatic Life					
2-Butanone (MEK)	-	-	-	-	5.00E-03

ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.

TABLE 24

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FOR ORGANIC CONSTITUENTS OF CONCERN - SITE 10

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
White-Tailed Deer					
2-Butanone (MEK)	9.70E-08	8.08E-05	2.87E-04	1.84E-01	1.85E-01
Benzo(a)anthracene	1.67E-05	3.28E-06	3.92E-05	-	5.91E-05
Benzo(b)fluoranthene	4.53E-04	6.18E-05	5.72E-04	-	1.09E-03
Fluoranthene	4.60E-06	2.08E-06	2.78E-05	-	3.45E-05
Phenanthrene	8.57E-06	7.82E-06	9.87E-05	-	1.15E-04
Pyrene	8.50E-06	4.22E-06	5.63E-05	-	6.90E-05
TOTAL	4.92E-04	1.60E-04	1.08E-03	1.84E-01	1.86E-01
Raccoons					
2-Butanone (MEK)	3.03E-07	6.06E-05	1.98E-04	1.84E-01	1.84E-01
Benzo(a)anthracene	5.21E-05	2.46E-06	2.84E-03	-	2.89E-03
Benzo(b)fluoranthene	1.42E-03	4.63E-05	3.70E+00	-	3.70E+00
Fluoranthene	1.44E-05	1.56E-06	2.07E-02	-	2.07E-02
Phenanthrene	2.68E-05	5.87E-06	3.48E-02	-	3.48E-02
Pyrene	2.66E-05	3.17E-06	2.48E-02	-	2.84E-02
TOTAL	1.54E-03	4.12E-04	3.79E+00	1.84E-01	3.97E+00
Aquatic Life					
2-Butanone (MEK)	-	-	-	-	1.67E-03
Benzo(a)anthracene	-	-	-	-	1.09E+00
Benzo(b)fluoranthene	-	-	-	-	1.03E+00
Fluoranthene	-	-	-	-	1.38E+00

TABLE 24

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
Phenanthrene	-	-	-	-	5.47E-01
Pyrene	-	-	-	-	3.96E-01
TOTAL	-	-	-	-	4.45E+00

ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.

TABLE 25

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FOR ORGANIC CONSTITUENTS OF CONCERN - SITE 11A

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
White-Tailed Deer					
Acetone	1.22E-06	2.44E-04	7.35E-03	-	7.59E-03
2-Butanone (MEK)	6.79E-08	5.66E-06	2.01E-04	1.29E-01	1.29E-01
2,4,6-trinitrotoluene	1.01E-05	9.64E-05	5.21E-03	-	5.32E-03
TOTAL	1.14E-05	3.46E-04	1.28E-02	1.29E-01	1.42E-01
Robins					
Acetone	1.14E-04	3.66E-04	1.25E-01	-	1.29E-01
2-Butanone (MEK)	6.36E-06	8.49E-06	7.26E-03	1.29E-01	1.29E-01
2,4,6-trinitrotoluene	9.50E-04	1.45E-04	5.15E+00	-	5.15E+00
TOTAL	1.07E-03	5.19E-04	5.28E+00	1.29E-01	5.41E+00
Aquatic Life					
Acetone	-	-	-	-	4.18E-02
2-Butanone (MEK)	-	-	-	-	1.17E-04
2,4,6-Trinitrotoluene	-	-	-	-	1.57E-01
TOTAL	-	-	-	-	1.99E-01

ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.

TABLE 26

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FOR ORGANIC CONSTITUENTS OF CONCERN - SITE 12

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
White-Tailed Deer					
Acetone	3.98E-06	7.98E-04	2.40E-02	-	2.48E-02
2-Butanone (MEK)	3.39E-08	2.83E-06	1.00E-04	6.45E-02	6.46E-02
Phenanthrene	6.10E-06	5.56E-07	7.02E-05	-	7.68E-05
Pyrene	7.00E-06	3.48E-07	4.64E-05	-	5.37E-05
TOTAL	1.71E-05	8.02E-04	2.42E-02	6.45E-02	8.96E-02
Robins					
Acetone	3.73E-04	1.20E-03	4.08E-01	-	4.09E-01
2-Butanone (MEK)	3.18E-06	4.24E-06	3.63E-03	6.45E-02	6.81E-02
Phenanthrene	5.71E-04	8.34E-07	1.30E+00	-	1.30E+00
Pyrene	6.56E-04	5.21E-07	1.23E+00	-	1.23E+00
TOTAL	1.60E-03	1.20E-03	2.94E+00	6.45E-02	3.01E+00
Aquatic Life					
Acetone	-	-	-	-	1.36E-01
2-Butanone (MEK)	-	-	-	-	5.84E-05
Phenanthrene	-	-	-	-	3.89E-02
Pyrene	-	-	-	-	3.26E-02
TOTAL	-	-	-	-	2.08E-01

ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.

TABLE 27

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FOR ORGANIC CONSTITUENTS OF CONCERN - SITE 14

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
White-Tailed Deer					
2-Butanone (MEK)	3.39E-08	2.83E-06	1.00E-04	6.45E-02	6.46E-02
Ethylbenzene	4.30E-05	3.17E-05	2.85E-03	1.21E+02	1.21E+02
Methylene Chloride	7.89E-06	1.34E-04	6.58E-03	6.15E+00	6.15E+00
m-Xylene	7.47E-05	5.06E-05	4.62E-03	6.48E+00	6.48E+00
o-Xylene	1.23E-05	9.48E-06	8.32E-04	5.52E-01	5.53E-01
p-Xylene	7.47E-05	5.49E-05	4.95E-03	1.22E+01	1.22E+01
Cyanide	1.91E-02	4.78E-01	2.15E+01	-	2.20E+01
TOTAL	1.93E-02	4.78E-01	2.15E+01	1.47E+02	1.69E+02
Robins					
2-Butanone (MEK)	3.18E-06	4.24E-06	3.63E-03	6.45E-02	6.81E-02
Ethylbenzene	4.04E-03	4.75E-05	6.92E-01	1.21E+02	1.22E+02
Methylene Chloride	7.39E-04	2.01E-04	9.32E-01	6.15E+00	7.08E+00
m-Xylene	7.00E-03	7.59E-05	1.01E+00	6.48E+00	7.49E+00
o-Xylene	1.15E-03	1.42E-05	1.76E+00	5.52E-01	2.31E+00
p-Xylene	7.00E-03	8.24E-05	1.09E+00	1.22E+01	1.33E+01
Cyanide	1.79E+00	7.17E-01	6.27E+03	-	6.30E+03
TOTAL	1.81E+00	7.17E-01	6.28E+03	1.47E+02	6.43E+03
Aquatic Life					
2-Butanone (MEK)	-	-	-	-	5.84E-05
Ethylbenzene	-	-	-	-	7.92E-02
Methylene Chloride	-	-	-	-	8.65E-04
m-Xylene	-	-	-	-	2.15E-01
o-Xylene	-	-	-	-	1.87E-02

TABLE 27

PAGE 2 OF 2

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
p-Xylene	-	-	-	-	3.17E-01
Cyanide	-	-	-	-	8.27E+01
TOTAL	-	-	-	-	8.33E+01

ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.

TABLE 28

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FOR ORGANIC CONSTITUENTS OF CONCERN - SITE 16

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
White-Tailed Deer					
Aroclor-1254	1.83E-02	2.07E-04	3.50E-02	-	5.35E-02
Aroclor-1260	1.08E-02	1.22E-04	8.64E-03	-	1.96E-02
TOTAL	2.92E-02	3.29E-04	4.36E-02	-	7.31E-02
Robins					
Aroclor-1254	1.72E+00	3.10E-04	8.58E+04	-	8.58E+04
Aroclor-1260	1.02E+00	1.84E-04	4.04E+04	-	4.04E+04
TOTAL	2.73E+00	4.94E-04	1.26E+05	-	1.26E+05
Aquatic Life					
Aroclor-1254	-	-	-	-	3.32E+02
Aroclor-1260	-	-	-	-	1.97E+02
TOTAL					5.29E+02

ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.

TABLE 29

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FOR ORGANIC CONSTITUENTS OF CONCERN - SITE 22A

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
White-Tailed Deer					
2-Butanone (MEK)	2.42E-08	2.02E-06	7.17E-05	4.61E-02	4.62E-02
Anthracene	1.57E-07	1.45E-08	1.83E-06	-	2.01E-06
Benzo(a)anthracene	3.67E-05	7.21E-07	8.62E-05	-	1.24E-04
Benzo(a)pyrene	1.73E-04	2.62E-06	1.10E-03	-	1.27E-03
Benzo(b)fluoranthene	9.60E-04	1.31E-05	1.21E-03	-	2.18E-03
Chrysene	2.63E-05	5.16E-07	6.17E-05	-	8.85E-05
Pentachlorophenol	1.71E-02	6.16E-04	8.19E-02	-	9.96E-02
Phenanthrene	4.00E-06	3.65E-07	4.60E-05	-	5.04E-05
Pyrene	9.83E-06	4.88E-07	6.51E-05	-	7.55E-05
2,3,7,8-TCDD	2.53E-01	3.39E-03	3.84E-01	-	6.41E-01
DDD	1.40E-06	2.04E-08	2.03E-06	-	3.46E-06
DDE	5.14E-07	9.83E-09	6.06E-06	-	6.58E-06
DDT	1.60E-05	1.90E-07	2.85E-05	-	4.47E-05
TOTAL	2.72E-01	4.02E-03	4.69E-01	4.61E-02	7.91E-01
Robins					
2-Butanone (MEK)	2.27E-06	3.03E-06	2.59E-03	4.61E-02	4.87E-02
Anthracene	1.47E-05	2.18E-08	2.57E-02	-	2.57E-02
Benzo(a)anthracene	3.44E-03	1.08E-06	3.28E-01	-	3.32E-01
Benzo(a)pyrene	1.63E-02	3.93E-06	3.14E+00	-	3.15E+00
Benzo(b)fluoranthene	9.00E-02	1.96E-05	4.12E+02	-	4.12E+02
Chrysene	2.46E-03	7.75E-07	7.96E+00	-	7.97E+00
Pentachlorophenol	1.60E+00	9.24E-04	6.28E+02	-	6.29E+02
Phenanthrene	3.75E-04	5.47E-07	8.52E-01	-	8.52E-01

TABLE 29

PAGE 2 OF 2

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
Pyrene	9.22E-04	7.32E-07	1.72E+00	-	1.73E+00
DDD	1.32E-04	3.07E-08	2.13E+00	-	2.13E+00
DDE	4.82E-05	1.48E-08	1.05E+00	-	1.05E+01
DDT	1.50E-03	2.85E-07	2.33E+01	-	2.33E+01
2,3,7,8-TCDD	2.37E+01	5.08E-03	5.59E+05	-	5.60E+05
TOTAL	2.55E+01	6.03E-03	5.61E+05	4.61E-02	5.60E+05
Aquatic Life					
2-Butanone	-	-	-	-	4.17E-05
Anthracene	-	-	-	-	2.65E-01
Benzo(a)anthracene	-	-	-	-	2.40E-01
Benzo(a)pyrene	-	-	-	-	2.95E-01
Benzo(b)fluoranthene	-	-	-	-	2.18E-01
Chrysene	-	-	-	-	8.26E-03
Pentachlorophenol	-	-	-	-	3.55E-02
Phenanthrene	-	-	-	-	2.55E-02
Pyrene	-	-	-	-	4.58E-02
DDD	-	-	-	-	2.82E-02
DDE	-	-	-	-	1.97E-05
DDT	-	-	-	-	1.71E+00
2,3,7,8-TCDD	-	-	-	-	5.08E+01
TOTAL	-	-	-	-	5.36E+01

ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.

TABLE 30

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FOR ORGANIC CONSTITUENTS OF CONCERN - SITE 36 (DOVE CREEK)

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
White-Tailed Deer					
Aldrin	3.67E-04	8.30E-05	8.82E-04	-	1.33E-03
Aroclor-1248	1.58E-03	1.79E-04	1.26E-03	-	3.02E-03
Aroclor-1254	1.46E-03	1.65E-04	2.79E-03	-	4.41E-03
Aroclor-1260	1.69E-04	1.91E-05	1.35E-04	-	3.22E-04
TOTAL	3.58E-03	4.45E-04	5.06E-03	-	9.08E-03
Raccoons					
Aldrin	1.15E-03	6.22E-05	6.56E-01	-	6.57E-01
Aroclor-1248	4.94E-03	1.34E-04	5.62E+01	-	5.62E+01
Aroclor-1254	4.56E-03	1.23E-04	1.30E+02	-	1.30E+02
Aroclor-1260	5.28E-04	1.43E-05	1.20E+01	-	1.20E+01
TOTAL	1.12E-02	3.34E-04	1.99E+02	-	1.99E+02
Aquatic Life					
Aldrin	-	-	-	-	1.88E+00
Aroclor-1248	-	-	-	-	2.87E+02
Aroclor-1254	-	-	-	-	2.65E+02
Aroclor-1260	-	-	-	-	3.07E+01
TOTAL	-	-	-	-	5.84E+02

ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.

TABLE 31

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FOR ORGANIC CONSTITUENTS OF CONCERN - SITE 36 (EAST POND)

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
White-Tailed Deer					
Acetone	2.06E-06	4.13E-03	1.24E-02	-	1.66E-02
2-Butanone (MEK)	7.81E-07	6.51E-04	2.31E-03	1.48E+00	1.49E+00
Methylene Chloride	3.00E-05	5.10E-03	2.51E-02	2.34E+01	2.34E+01
Acenaphthene	6.22E-04	1.31E-03	1.46E-02	-	1.66E-02
Anthracene	7.37E-06	6.83E-06	8.62E-05	-	1.00E-04
Benzo(a)anthracene	2.60E-04	5.11E-05	6.11E-04	-	9.22E-04
Benzo(a)pyrene	6.40E-04	9.67E-05	4.05E-03	-	4.79E-03
Benzo(b)fluoranthene	5.20E-03	7.08E-04	6.56E-03	-	1.25E-02
Bis(2-ethylhexyl)phthalate	5.71E-05	2.09E-05	2.74E-04	-	3.52E-04
Chrysene	1.09E-04	2.14E-05	2.56E-04	-	3.86E-04
Dibenzofuran	2.63E-03	4.05E-03	4.79E-02	-	5.46E-02
Fluoranthene	1.61E-04	7.28E-05	9.75E-04	-	1.21E-03
Fluorene	2.93E-04	4.11E-04	4.88E-03	-	5.59E-03
2-Methylnaphthalene	1.55E-04	3.59E-04	3.98E-03	-	4.50E-03
Naphthalene	2.03E-04	1.17E-03	1.09E-02	-	1.23E-02
Phenanthrene	9.52E-04	8.69E-04	1.10E-02	-	1.28E-02
Pyrene	2.32E-04	1.15E-04	1.53E-03	-	1.88E-03
Aldrin	1.57E-03	3.56E-04	3.78E-03	-	5.71E-03
Aroclor-1248	7.47E-03	8.43E-04	5.95E-03	-	1.43E-02
Aroclor-1254	1.42E-02	1.61E-03	2.72E-02	-	4.30E-02
Aroclor-1260	1.39E-03	1.57E-04	1.10E-03	-	2.65E-03
TOTAL	3.62E-02	2.21E-02	1.85E-01	2.49E+01	2.51E+01

TABLE 31

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
Raccoons					
Acetone	6.43E-06	3.10E-03	4.02E-03	-	7.12E-03
2-Butanone (MEK)	2.44E-06	4.88E-04	1.59E-03	1.48E+00	1.49E+00
Methylene chloride	9.39E-05	3.83E-03	6.69E-02	2.34E+01	2.34E+01
Acenaphthene	1.94E-03	9.86E-04	1.28E+00	-	1.28E+00
Anthracene	2.30E-05	5.12E-06	2.30E-02	-	2.31E-02
Benzo(a)anthracene	8.13E-04	3.84E-05	4.43E-02	-	4.52E-02
Benzo(a)pyrene	2.00E-03	7.26E-05	2.21E-01	-	2.23E-01
Benzo(b)fluoranthene	1.63E-02	5.31E-04	4.25E+01	-	4.25E+01
Bis(2-ethylhexyl)phthalate	1.78E-04	1.56E-05	7.04E-01	-	7.04E-01
Chrysene	3.40E-04	1.60E-05	6.28E-01	-	6.29E-01
Dibenzofuran	8.21E-03	3.03E-03	1.36E+01	-	1.37E+01
Fluoranthene	5.04E-04	5.46E-05	7.25E-01	-	7.25E-01
Fluorene	9.17E-04	3.08E-04	1.32E+00	-	1.33E+00
2-Methylnaphthalene	4.83E-04	2.70E-04	8.78E-02	-	8.86E-02
Naphthalene	6.35E-04	8.78E-04	1.25E+00	-	1.25E+00
Phenanthrene	2.98E-03	6.52E-04	3.86E+00	-	3.87E+00
Pyrene	7.24E-04	8.63E-05	7.74E-01	-	7.75E-01
Aldrin	4.91E-03	2.67E-04	2.81E+00	-	2.82E+00
Aroclor-1248	2.33E-02	6.32E-04	2.65E+02	-	2.65E+02
Aroclor-1254	4.44E-02	1.20E-03	1.27E+03	-	1.27E+03
Aroclor-1260	4.33E-03	1.17E-04	9.83E+01	-	9.84E+01
TOTAL	1.13E-01	1.66E-02	1.70E+03	2.49E+01	1.73E+03

TABLE 31

PAGE 3 OF 4

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
Aquatic Life					
Acetone	-	-	-	-	7.07E-01
2-Butanone	-	-	-	-	1.34E-02
Methylene Chloride	-	-	-	-	3.29E-02
Acenaphthene	-	-	-	-	3.59E+01
Anthracene	-	-	-	-	1.24E+02
Benzo(a)anthracene	-	-	-	-	1.70E+01
Benzo(a)pyrene	-	-	-	-	1.09E+01
Benzo(b)fluoranthene	-	-	-	-	1.18E+01
Bis(2-ethylhexyl)phthalate	-	-	-	-	5.95E-02
Chrysene	-	-	-	-	3.42E-01
Dibenzofuran	-	-	-	-	6.82E-01
Fluoranthene	-	-	-	-	4.85E+01
Fluorene	-	-	-	-	1.23E+01
2-Methylnaphthalene	-	-	-	-	2.93E-02
Naphthalene	-	-	-	-	1.28E+01
Phenanthrene	-	-	-	-	6.08E+01
Pyrene	-	-	-	-	1.08E+01
Aldrin	-	-	-	-	8.08E+00
Aroclor-1248	-	-	-	-	1.36E+03

TABLE 31

PAGE 4 OF 4

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
Aroclor-1254	-	-	-	-	2.58E+03
Aroclor-1260	-	-	-	-	2.52E+03
TOTAL	-	-	-	-	4.55E+03

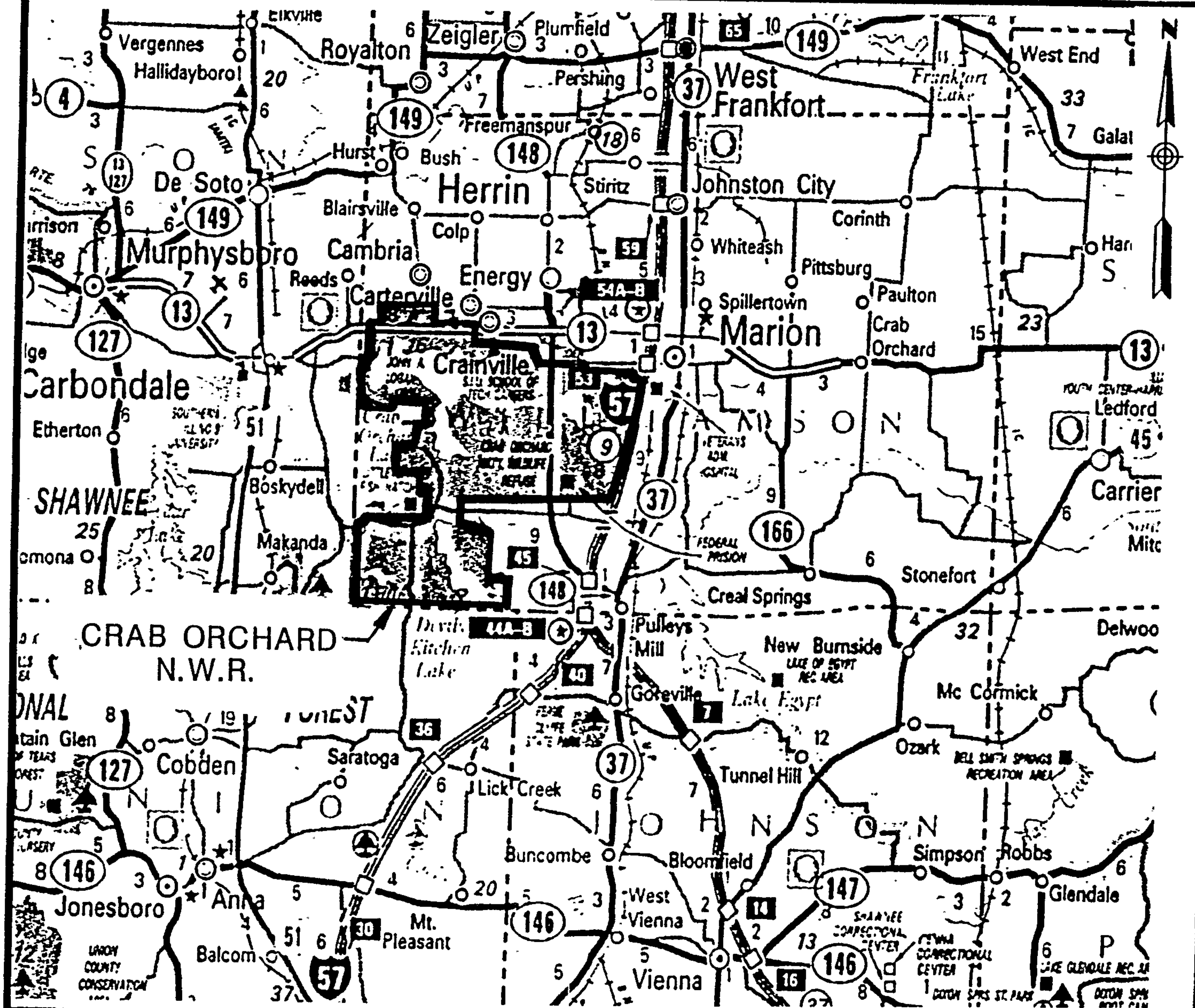
ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.

TABLE 32

ECOLOGICAL RISK INDICES (*ERIs*) COMPUTED FOR ORGANIC CONSTITUENTS OF CONCERN - SITE 36 (PRIMARY LAGOON)

Target Organism/ Constituent of Concern	ERI_{soil}	ERI_{dw}	ERI_{food}	ERI_{inh}	ERI_{sum}
White-Tailed Deer					
Acetone	1.59E-06	3.19E-03	9.61E-03	-	1.28E-02
Aroclor-1248	2.67E-05	3.01E-06	2.12E-05	-	5.09E-05
Aroclor-1254	3.20E-05	3.61E-06	6.11E-05	-	9.68E-05
TOTAL	6.03E-05	3.20E-03	9.69E-03	-	1.30E-02
Racoons					
Acetone	4.97E-06	2.39E-03	3.11E-03	-	5.51E+03
Aroclor-1248	8.33E-05	2.26E-06	9.48E-01	-	9.48E-01
Aroclor-1254	1.00E-04	2.71E-06	2.86E+00	-	2.86E+00
TOTAL	1.88E-04	2.40E-03	3.81E+00	-	3.81E+00
Aquatic Life					
Acetone	-	-	-	-	5.46E-01
Aroclor-1248	-	-	-	-	4.84E+00
Aroclor-1254	-	-	-	-	5.81E+00
TOTAL	-	-	-	-	1.12E+01

ERI_{soil} - *ERI* for incidental ingestion of soils
ERI_{dw} - *ERI* for drinking water
ERI_{food} - *ERI* for ingestion of food (animal and plant)
$ERI_{sum} = ERI_{soil} + ERI_{dw} + ERI_{food}$
ERI_{sum} for Aquatic Life based on predicted water column concentrations vs CTV.



VICINITY MAP

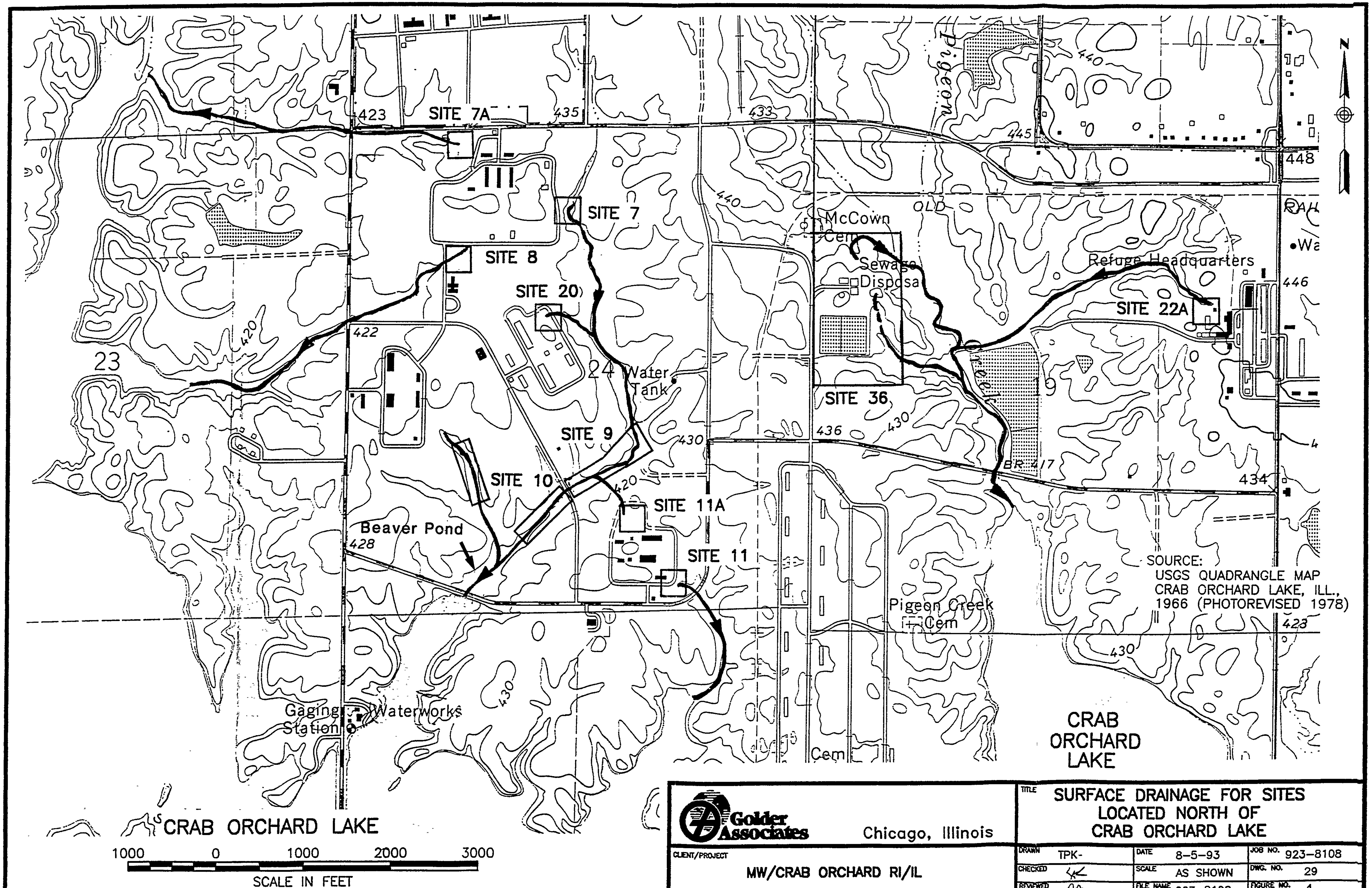
0 50 100
MILES

BASE MAP FROM: ILLINOIS DEPT. OF TRANSPORTATION 1991.

SITE PLAN

0 6 12
SCALE IN MILES

CLIENT/PROJECT: MW/CRAB ORCHARD RI/IL			Golder Associates, Chicago, Illinois		TITLE: REFUGE LOCATION MAP	
DRAWN: TPK	CHECKED: RA	REVIEWED: RA	DATE: 3-16-93	SCALE: AS SHOWN	FILE NAME: 923-8108	JOB NO.: 923-8108; DWG NO.: 3; FIGURE: 1



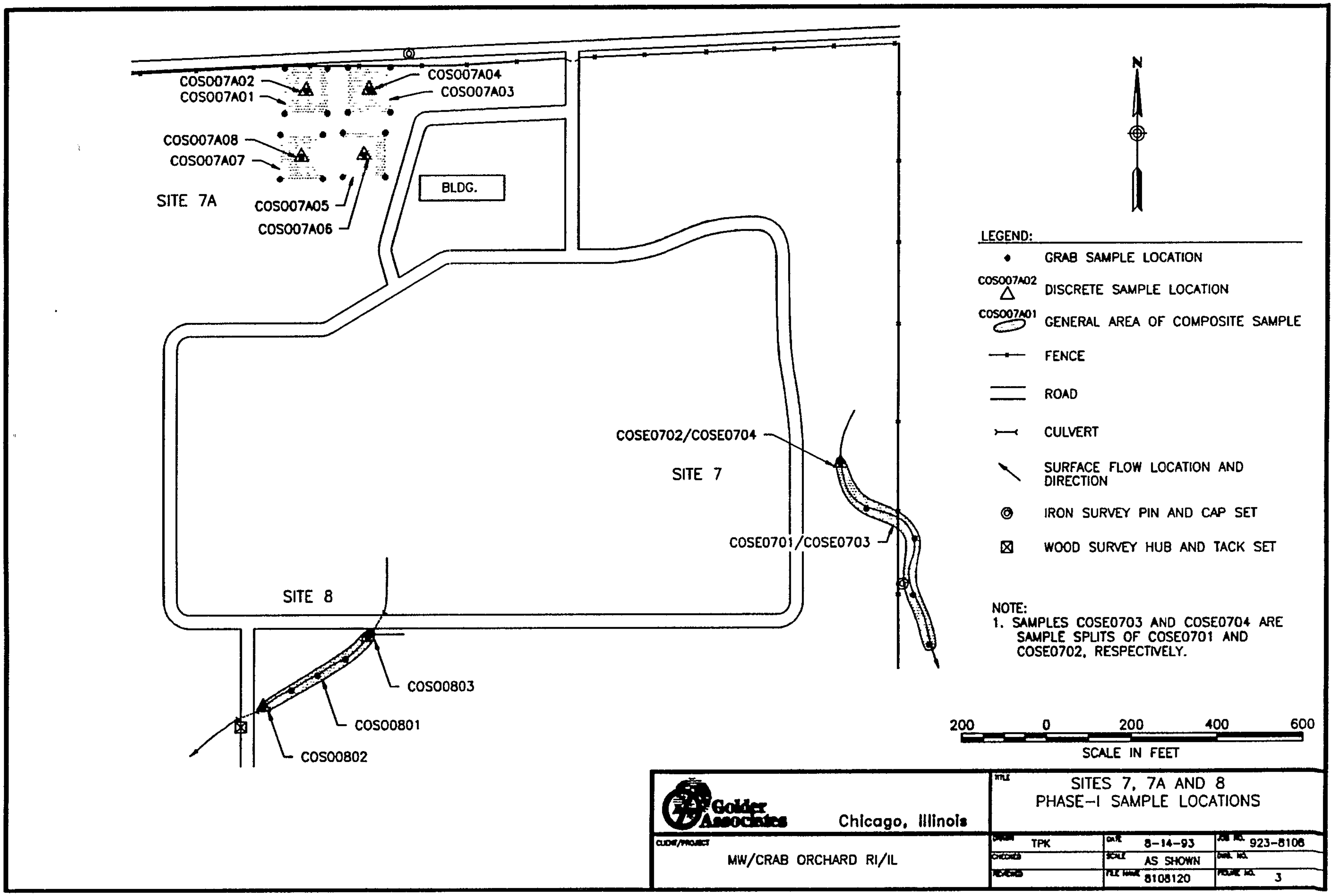
SOURCE:
USGS QUADRANGLE MAP
CRAB ORCHARD LAKE, ILL.,
1966 (PHOTOREVISED 1978)

Golder Associates
Chicago, Illinois

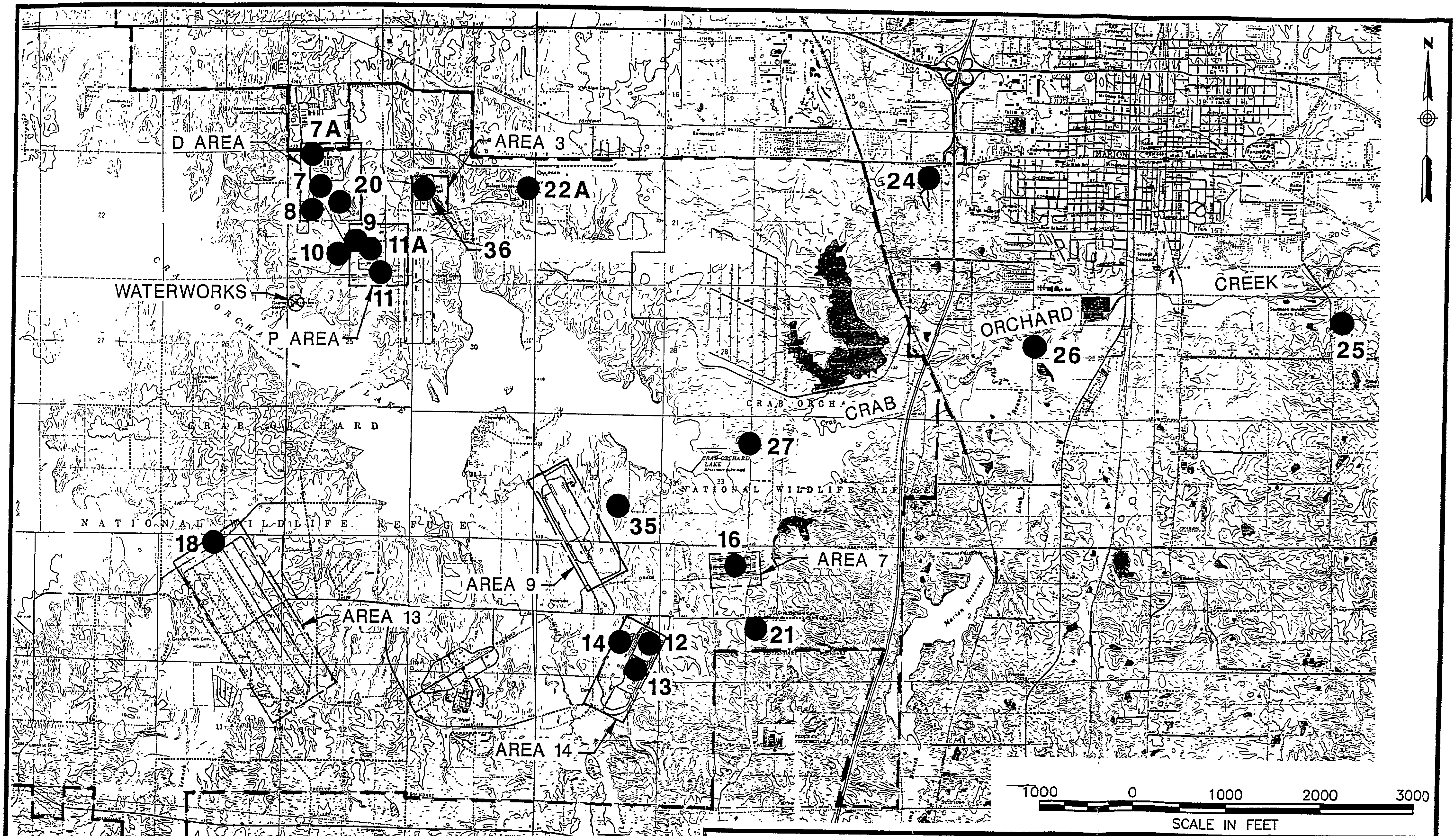
CLIENT/PROJECT: MW/CRAB ORCHARD RI/IL

TITLE: SURFACE DRAINAGE FOR SITES LOCATED NORTH OF CRAB ORCHARD LAKE

DRAWN	TPK-	DATE	8-5-93	JOB NO.	923-8108
CHECKED	SK	SCALE	AS SHOWN	DWG. NO.	29
REVIEWED	RA	FILE NAME	923-8108	FIGURE NO.	4



COSOO7A02
COSOO7A01
COSOO7A04
COSOO7A03
COSOO7A08
COSOO7A07
SITE 7A
COSOO7A05
COSOO7A06
BLDG.
N
LEGEND:
GRAB SAMPLE LOCATION
COSOO7A02
DISCRETE SAMPLE LOCATION
COSOO7A01
GENERAL AREA OF COMPOSITE SAMPLE
FENCE
ROAD
CULVERT
SURFACE FLOW LOCATION AND DIRECTION
IRON SURVEY PIN AND CAP SET
WOOD SURVEY HUB AND TACK SET
COSE0702/COSE0704
SITE 7
COSE0701/COSE0703
NOTE:
1. SAMPLES COSE0703 AND COSE0704 ARE SAMPLE SPLITS OF COSE0701 AND COSE0702, RESPECTIVELY.
SITE 8
COSO0803
COSO0801
COSO0802
200 0 200 400 600
SCALE IN FEET
Golder Associates
Chicago, Illinois
CLIENT/PROJECT
MW/CRAB ORCHARD RI/IL
TITLE
SITES 7, 7A AND 8
PHASE-I SAMPLE LOCATIONS
DRAWN TPK
CHECKED
REVIEWED
DATE 8-14-93
SCALE AS SHOWN
FILE NAME 8108120
JOB NO. 923-8106
DWG. NO.
FIGURE NO. 3



— — — REFUGE BOUNDARY

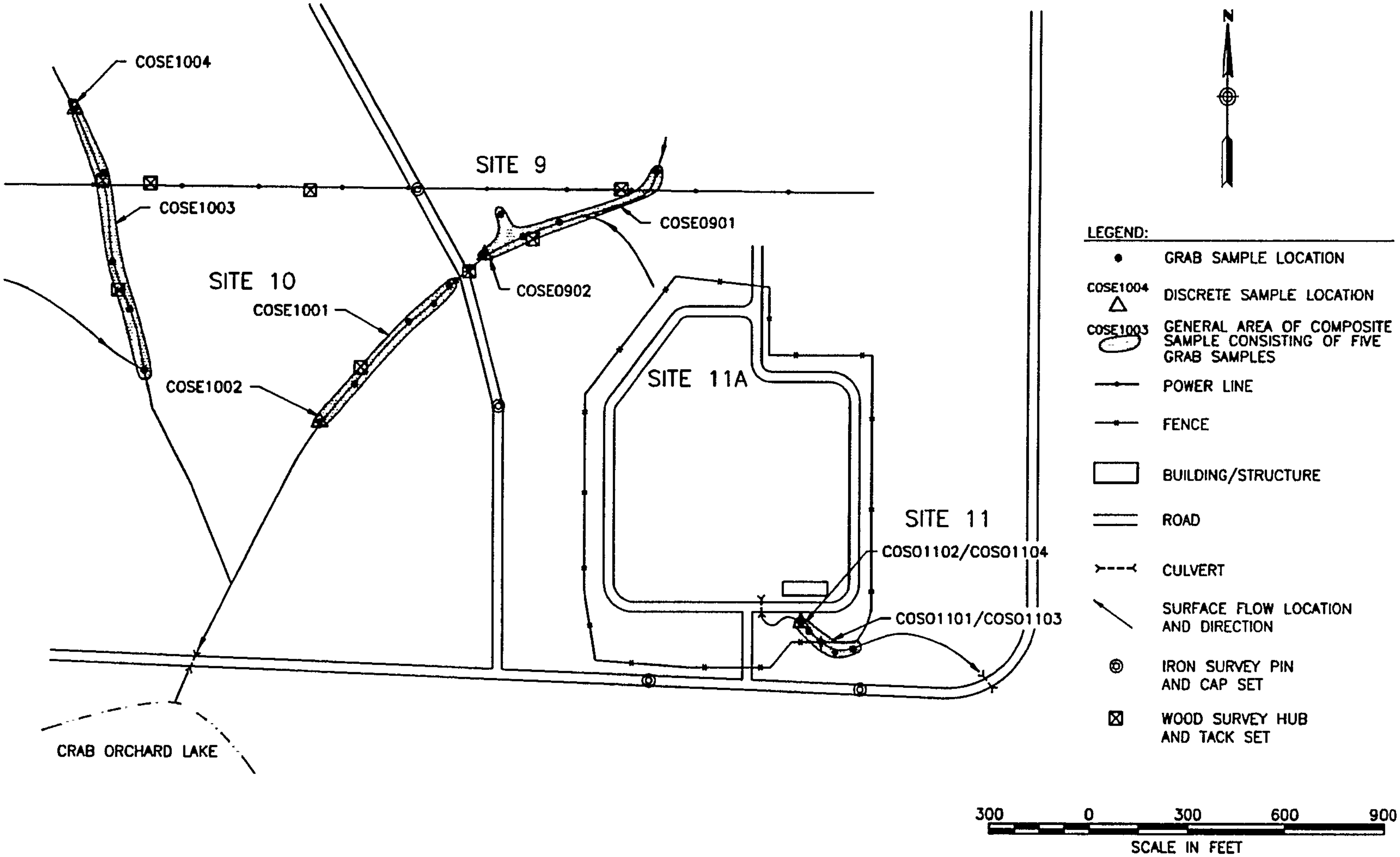
● SITE LOCATION

NOTE: SITE 34 IS CRAB ORCHARD LAKE.

MAP SOURCE: U.S.G.S. 7.5 MINUTE SERIES QUADRANGLE MAPS MARION, ILL. 1966, PHOTOREVISED 1990, AND CRAB ORCHARD LAKE, ILL. 1966, PHOTOREVISED 1978.

Golder Associates Chicago, Illinois

TITLE	MISC AREAS OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE		
CLIENT/PROJECT	MW/CRAB ORCHARD RI/IL		
DRAWN TPK	DATE 11-6-92	JOB NO. 923-8108	
CHECKED RA	SCALE AS SHOWN	DWG. NO. 6	
REVIEWED RA	FILE NAME 923-8108	FIGURE NO. 2	



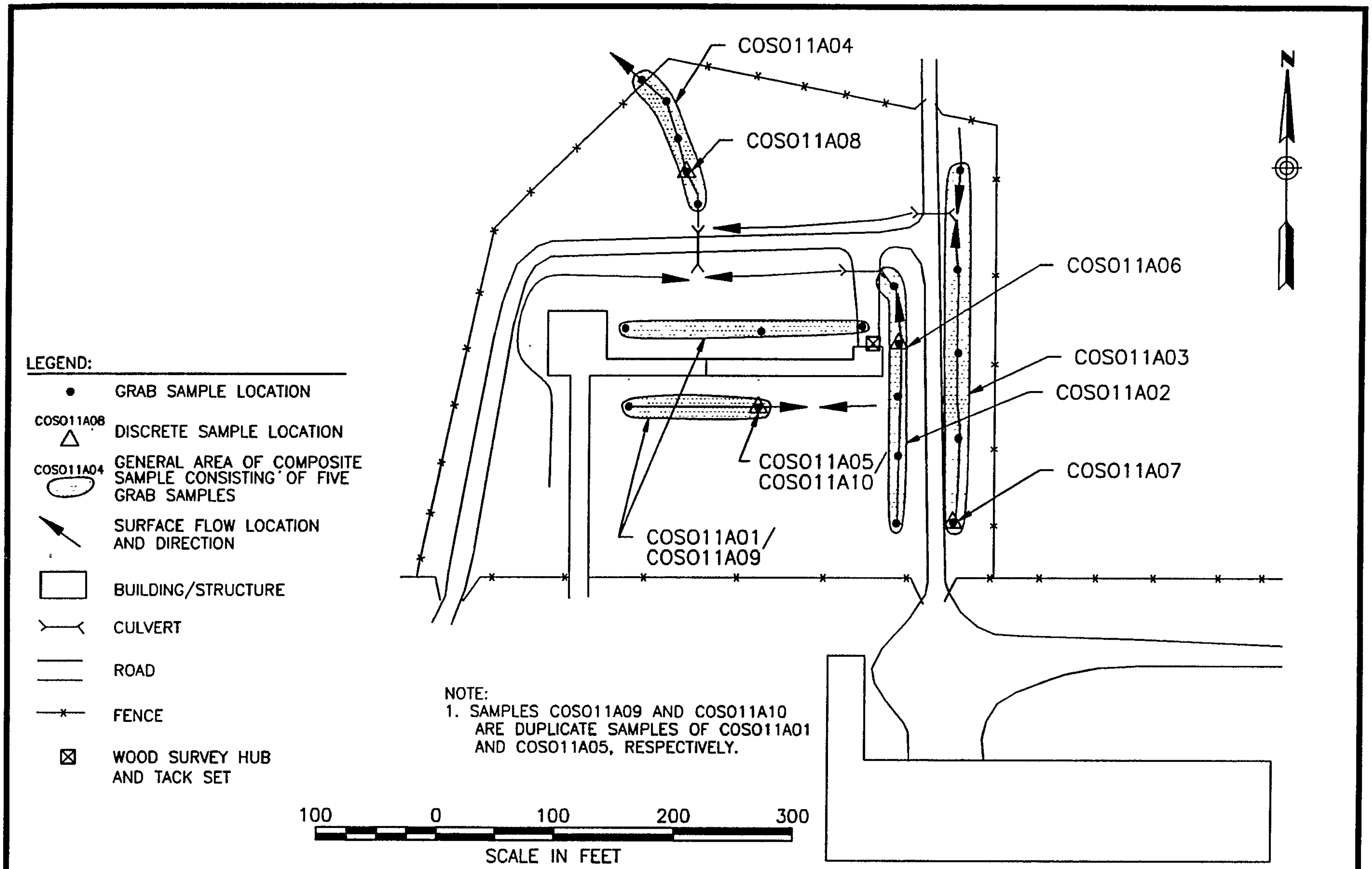
NOTE:
1. SAMPLES COSO1103 AND COSO1104 ARE SAMPLE SPLITS OF COSO1101 AND COSO1102, RESPECTIVELY.

Golder Associates
Chicago, Illinois

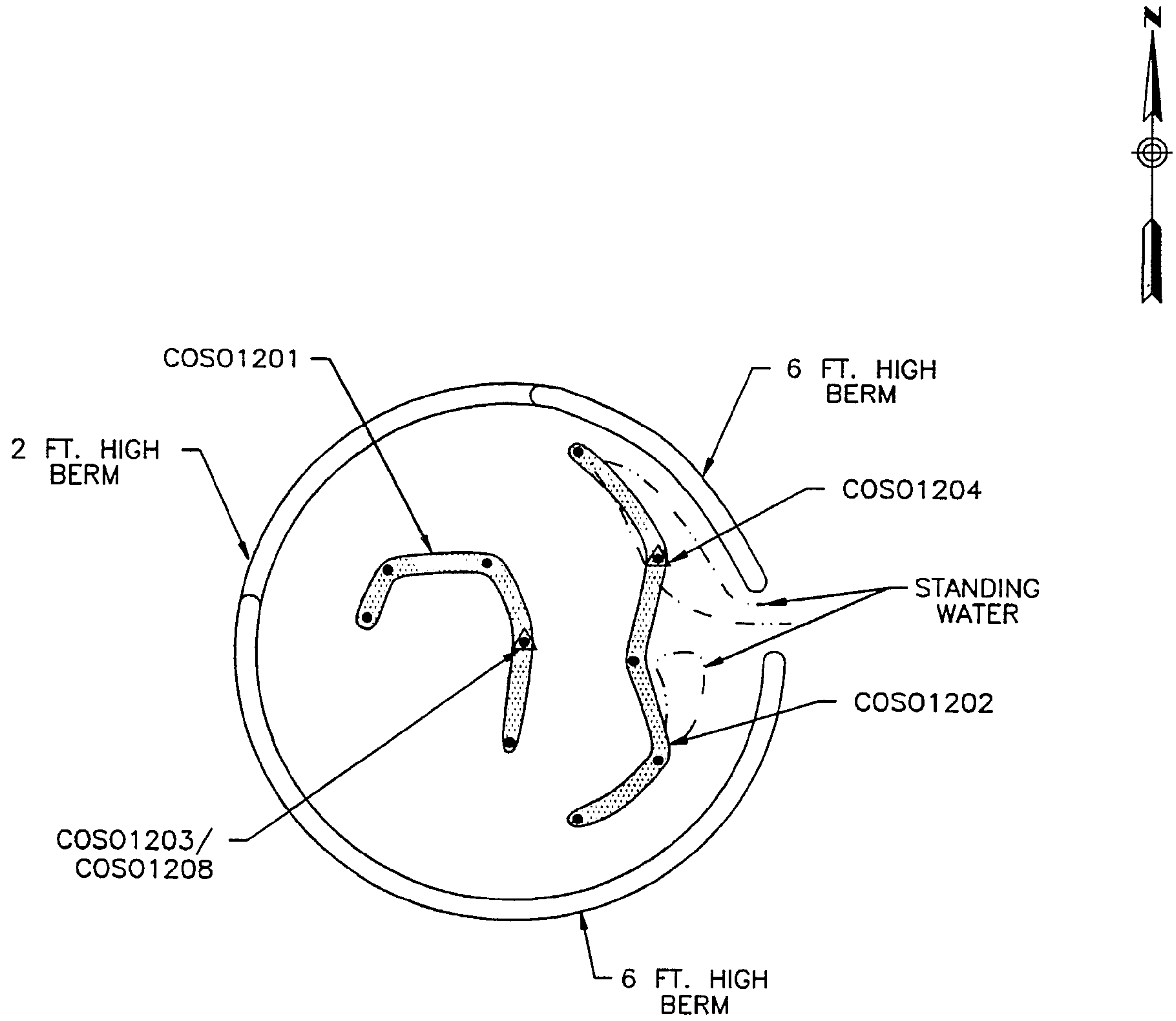
TITLE: SITES 9, 10, AND 11
PHASE-I SAMPLE LOCATIONS

CLIENT/PROJECT: MW/CRAB ORCHARD RI/IL

DRAWN: TPK	DATE: 8-24-93	JOB NO.: 923-8108	
CHECKED:	SCALE: AS SHOWN	DWG. NO.:	
REVIEWED:	FILE NAME: 8108121	FIGURE NO.: 5	



CLIENT/PROJECT			Golder Associates Chicago, Illinois			TITLE		
MW/CRAB ORCHARD RI/IL						SITE 11A PHASE-I SAMPLE LOCATIONS		
DRAWN TPK	CHECKED	REVIEWED	DATE 8-24-93	SCALE AS SHOWN	FILE NAME 8108107	JOB NO. 923-8108	DWG NO.	FIGURE 6



NOTE:
1. SAMPLE COSO1208 IS A DUPLICATE OF COSO1203.

LEGEND:

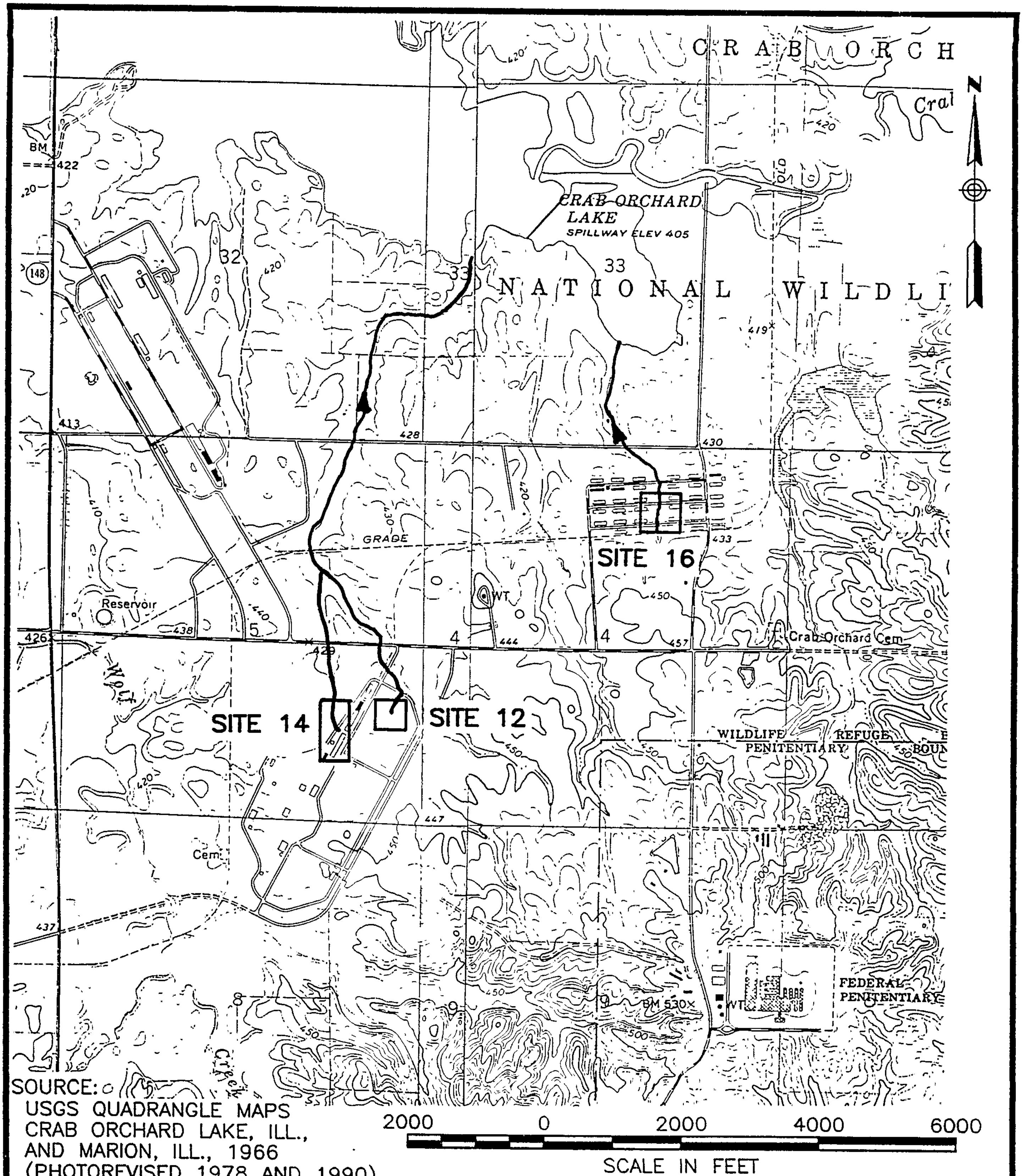
•	GRAB SAMPLE LOCATION
COSO1203 △	DISCRETE SAMPLE LOCATION
COSO1201 (shaded area)	GENERAL AREA OF COMPOSITE SAMPLE

50 0 50 100 150

SCALE IN FEET

Golder Associates Chicago, Illinois

CLIENT/PROJECT: MW/CRAB ORCHARD RI/IL	TITLE: SITE 12 PHASE-I SAMPLE LOCATIONS		
DRAWN: TPK	DATE: 8-14-93	JOB NO. 923-8108	
CHECKED: -	SCALE: AS SHOWN	DWG NO.	
REVIEWED	FILE NAME: 8108119	FIGURE NO. 7	



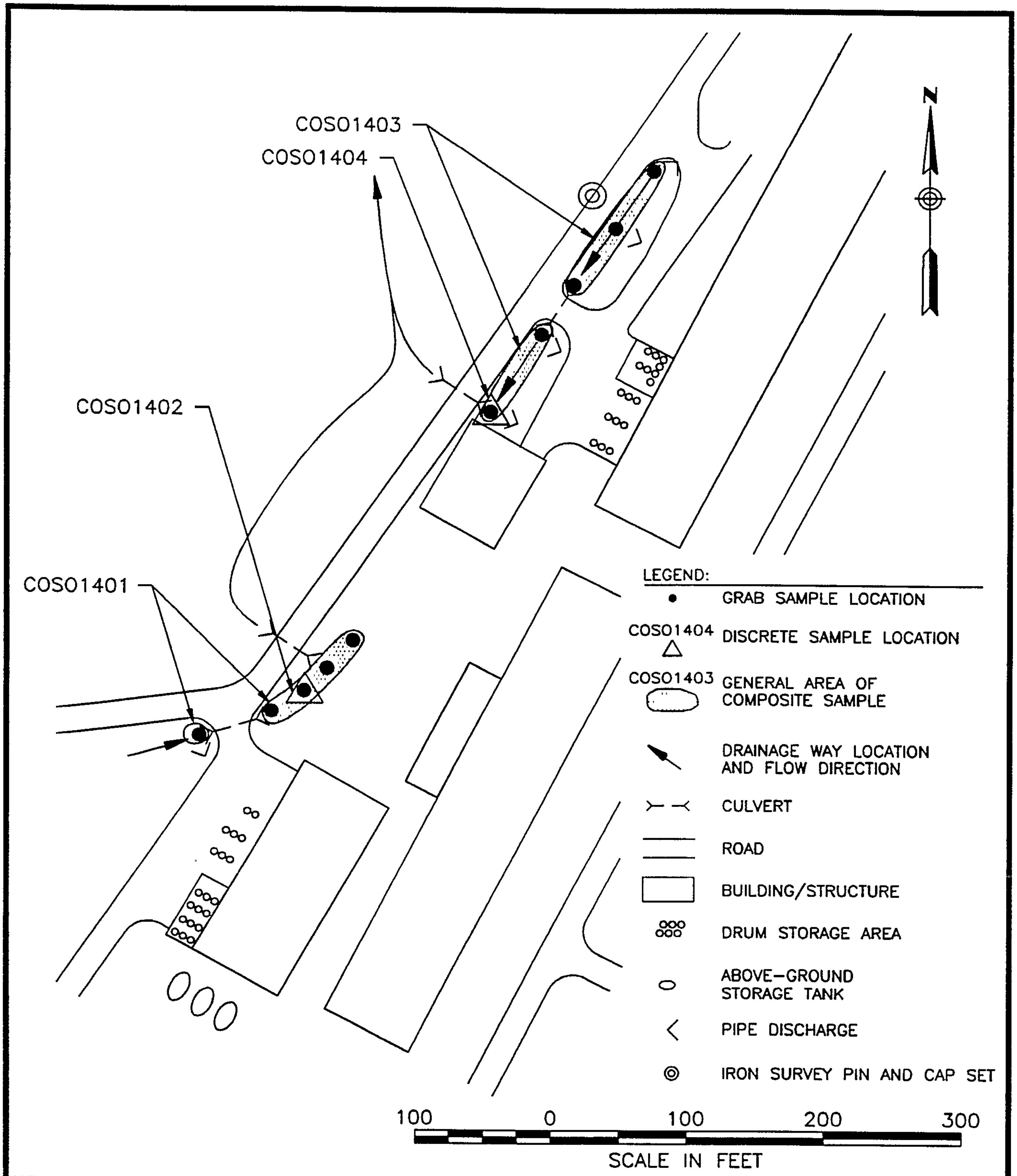
SOURCE:
USGS QUADRANGLE MAPS
CRAB ORCHARD LAKE, ILL.,
AND MARION, ILL., 1966
(PHOTOREVISED 1978 AND 1990)

Golder Associates Chicago, Illinois

TITLE: SURFACE DRAINAGE FOR SITES LOCATED SOUTH OF CRAB ORCHARD LAKE

CLIENT/PROJECT: MW/CRAB ORCHARD RI/IL

DRAWN	TPK	DATE	8-5-93	JOB NO.	923-8108
CHECKED	LAK	SCALE	AS SHOWN	DWG NO.	28
REVIEWED	RA	FILE NAME	923-8108	FIGURE NO.	8

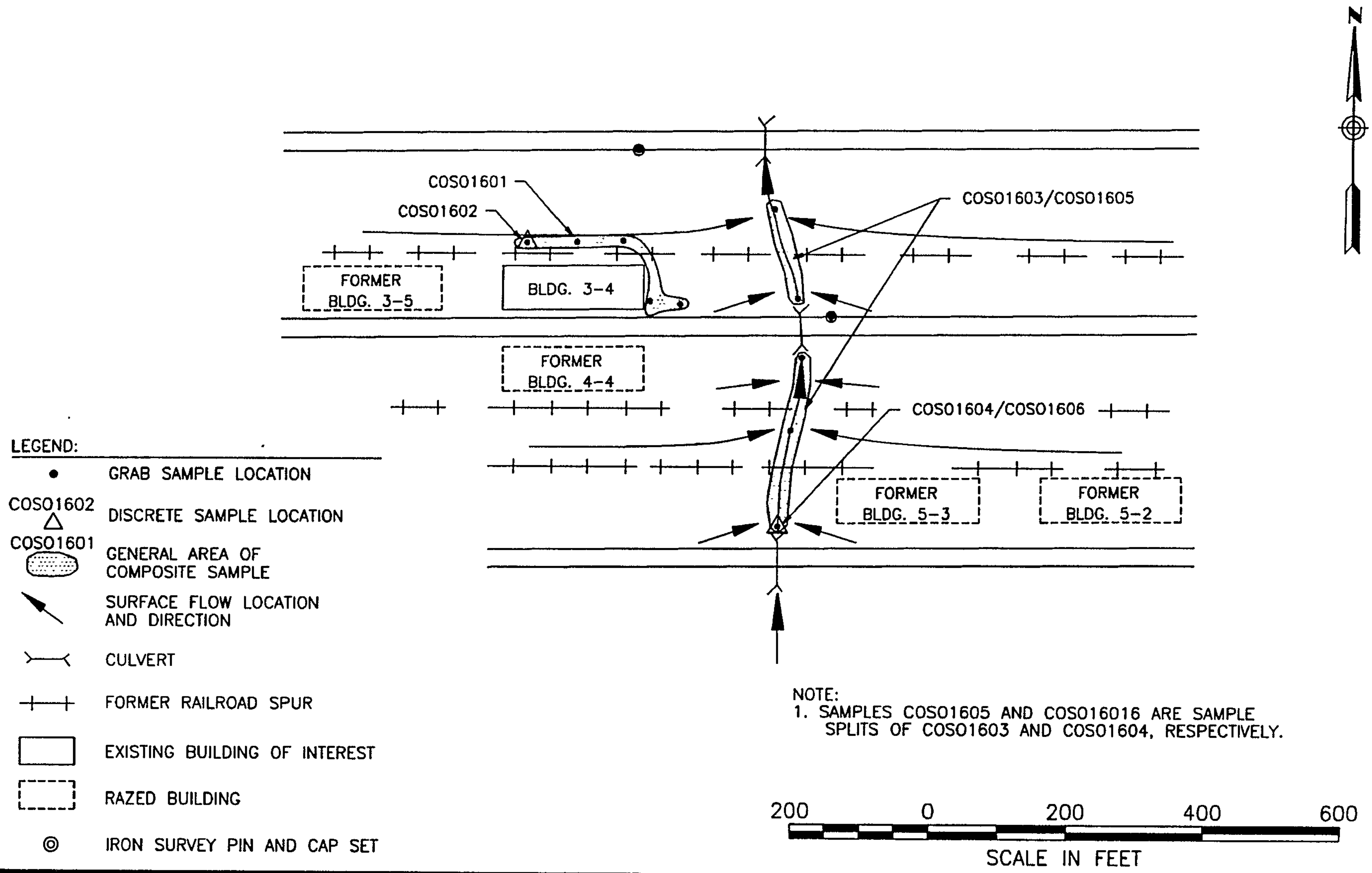


Golder Associates
Chicago, Illinois

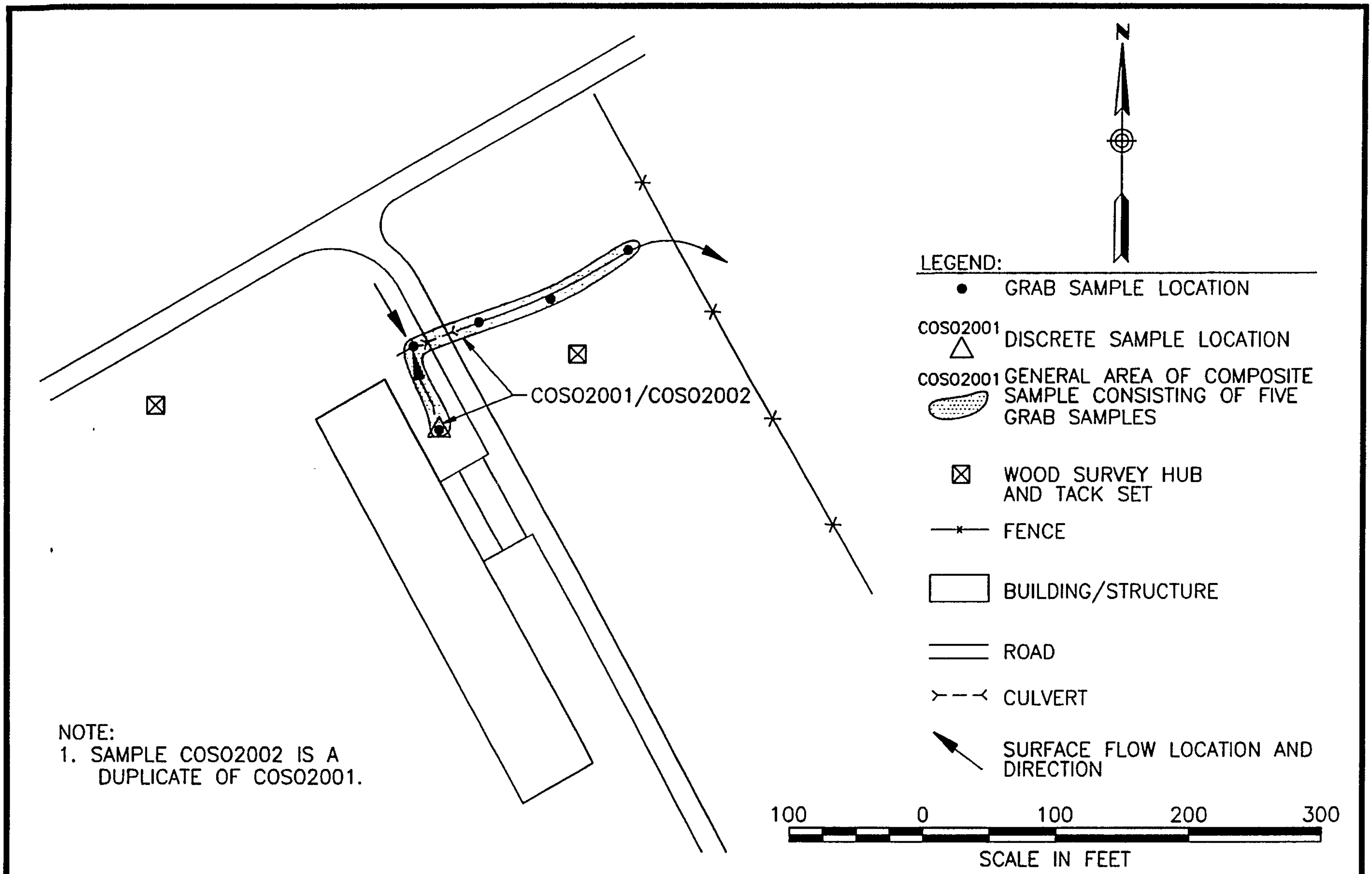
CLIENT/PROJECT
MW/CRAB ORCHARD RI/IL

TITLE
SITE 14
PHASE-I SAMPLE LOCATIONS

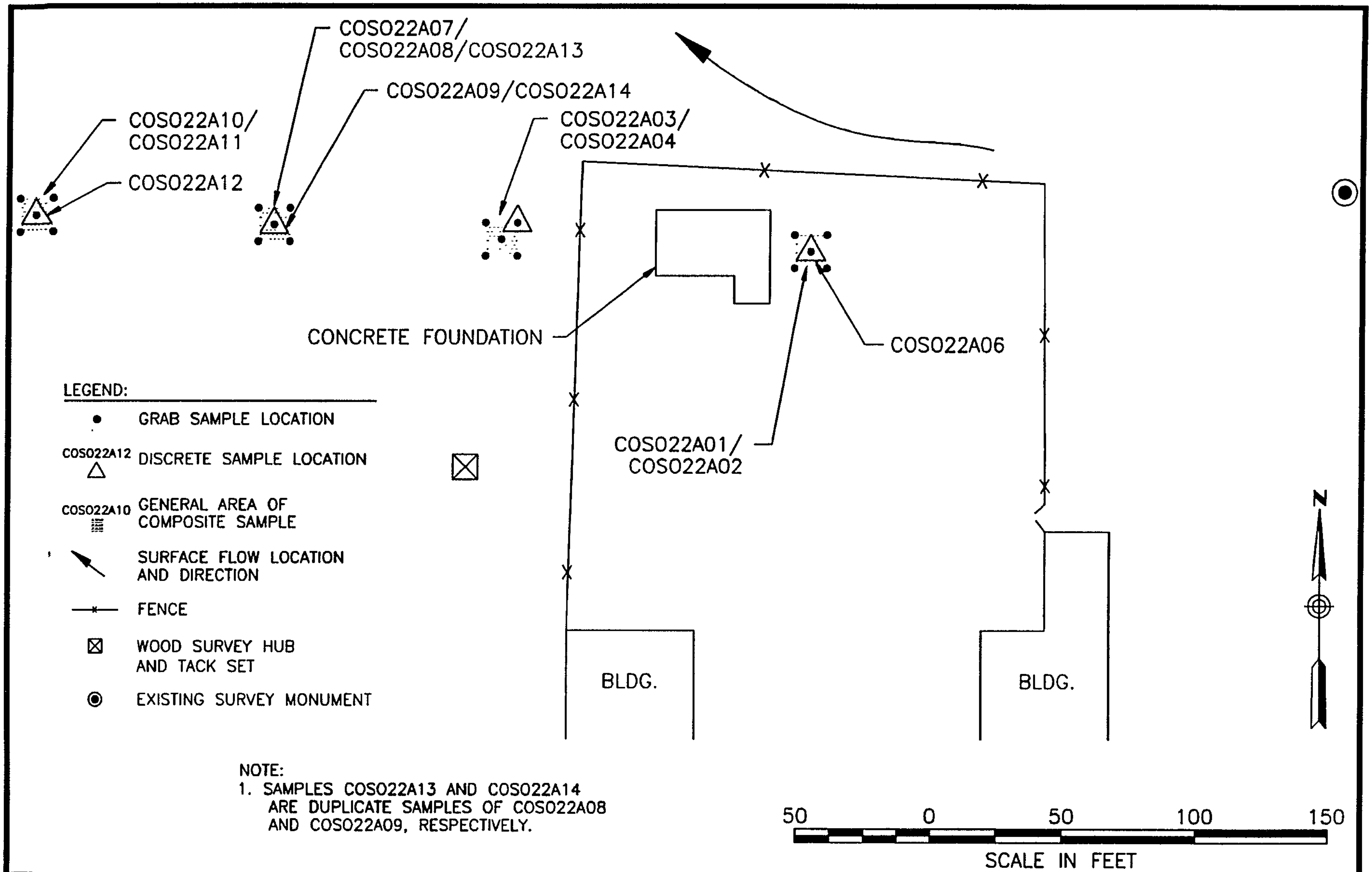
DRAWN	TPK	DATE	8-14-93	JOB NO.	923-8108
CHECKED	-	SCALE	AS SHOWN	DWG NO.	
REVIEWED		FILE NAME	8108111	FIGURE NO.	9



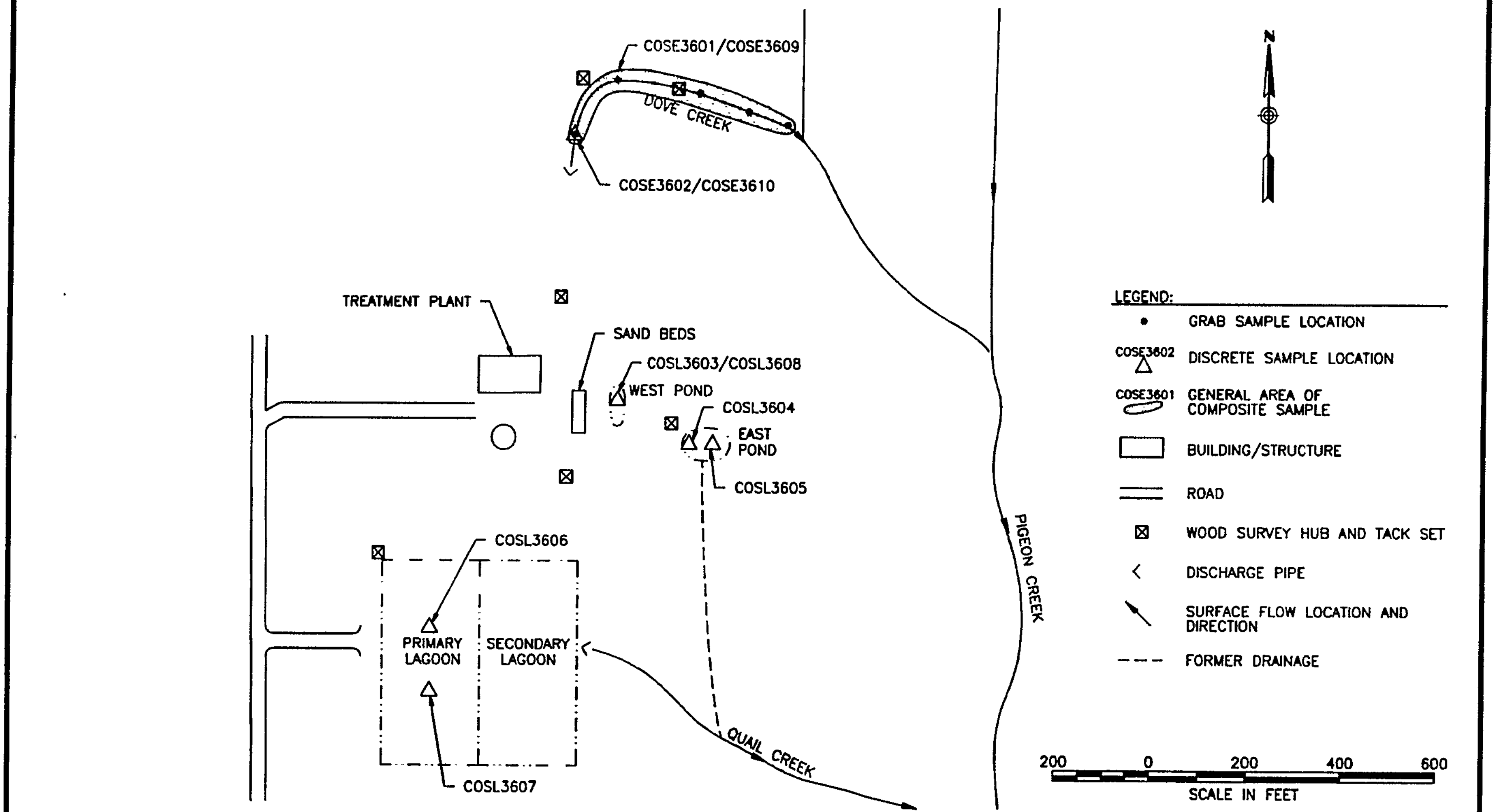
CLIENT/PROJECT						TITLE		
MW/CRAB ORCHARD RI/IL			Golder Associates Chicago, Illinois			SITE 16 PHASE-I SAMPLE LOCATIONS		
DRAWN TPK	CHECKED	REVIEWED	DATE 8-14-93	SCALE AS SHOWN	FILE NAME 8108112	JOB NO. 923-8108	DWG NO.	FIGURE 10



CLIENT/PROJECT						TITLE		
MW/CRAB ORCHARD RI /IL			Golder Associates Chicago, Illinois			SITE 20 PHASE-I SAMPLE LOCATIONS		
DRAWN TPK	CHECKED	REVIEWED	DATE 8-23-93	SCALE AS SHOWN	FILE NAME 8108122	JOB NO. 923-8108	DWG NO.	FIGURE 11



CLIENT/PROJECT						TITLE		
MW/CRAB ORCHARD RI/IL			Golder Associates Chicago, Illinois			SITE 22A PHASE-I SAMPLE LOCATIONS		
DRAWN TPK	CHECKED	REVIEWED	DATE 8-14-93	SCALE AS SHOWN	FILE NAME 8108104	JOB NO. 923-8108	DWG NO.	FIGURE 12



NOTES:
1. SAMPLES COSE3609 AND COSE3610 ARE DUPLICATES OF COSE3601 AND COSE3602, RESPECTIVELY.
2. SAMPLE COSL3608 IS A SAMPLE SPLIT OF COSL3603.

Golder Associates Chicago, Illinois

CLIENT/PROJECT: MW/CRAB ORCHARD RI/IL

TITLE: SITE 36 PHASE-I SAMPLE LOCATIONS

DRAWN	TPK	DATE	8-14-93	JOB NO.	923-8108
CHECKED		SCALE	AS SHOWN	DWG. NO.	
REVIEWED		FILE NAME	8108123	FIGURE NO.	13

APPENDIX I

COMMON SPECIES AND ASSOCIATED HABITATS

APPENDIX I

HABITAT TYPE, MISCELLANEOUS AREA OPERABLE UNITS (MAOU) THAT CONTAIN THE HABITAT TYPE, AND COMMON SPECIES OF VEGETATION, BIRDS, MAMMALS, AND HERPETOFAUNA ASSOCIATED WITH THE HABITAT TYPE

HABITAT TYPE	MAOU SITES THAT CONTAIN THE HABITAT TYPE	VEGETATION[a]	
Deciduous Forest			
Upland Hardwood	7, 21	Canopy:	White oak, black oak, southern red oak, pignut hickory, shagbark hickory, bitternut hickory, white ash, sugar maple
		Shrub/Understory:	Common blackberry, sumac, sassafras, slippery elm, hornbeam, paw paw, bladdernut
		Ground Cover:	Grasses, sedges, nettles, composites, legumes and poison ivy (see Ulaszek 1988 for detailed information)
Bottomland Hardwood	9, 10, 27, 36	Canopy:	Sycamore, pin oak, swamp whiteoak, hackberry, cottonwood
		Shrub/understory:	Spice bush, elder
		Ground Cover:	Grasses, sedges, day flowers, and smartweeds
Old Field	12, 13, 14, 18, 22A, 36	Woody Vegetation:	Eastern red cedar, pin oak, black cherry, persimmon, autumn olive, staghorn sumac, roughleaf dogwood, white ash, and multiflora rose
		Herbaceous Vegetation:	Grasses (brome, fescue, timothy, bluegrass), forbs (dairy, fleabane, goldenrod, thistle) and poison ivy
Industrial Facilities	7, 7A, 8, 11, 11A, 14, 16, 18, 20	Same as Old Field Habitat Type	
Agricultural Fields	21, 35	Pasture, red clover, tame grasses such as fescue and bluegrass, corn, milo, soybeans and winter wheat	

HABITAT TYPE	MAOU SITES THAT CONTAIN THE HABITAT TYPE	BREEDING BIRDS[b]
Deciduous Forest		
Upland Hardwood	7, 21	Rufous-sided Towhee[s], Great-crested Flycatcher[s], Blue Jay[r], Northern Cardinal[r], Red-eyed Vireo[s], Blue-gray Gnatcatcher[s], Parula Warbler[s], House Wren[s], Carolina Wren[s], Downy Woodpecker[r], Hairy Woodpecker[r], Red-bellied Woodpecker[r], Wood Thrush[s], Tufted Titmouse[r], Carolina Chickadee[r], Yellow-billed Cuckoo[s], White-breasted Nuthatch[r], Summer Tanager[s], Great Horned Owl[r], Barred Owl[r], Red-shouldered Hawk[r], Broad-winged Hawk[s], Northern Bobwhite[r]
Bottomland Hardwood	9, 10, 27, 36	Rufous-sided Towhee[s], Great-crested Flycatcher[s], Blue Jay[r], Red-eyed Vireo[s], Blue-gray Gnatcatcher[s], Parula warbler[s], Prothonotary Warbler[s], Louisiana Waterthrush[s], Downy Woodpecker[r], Hairy Woodpecker[r], Red-bellied Woodpecker[r], Wood Thrush[s], Tufted Titmouse[r], Carolina Chickadee[r], Yellow-bellied Cuckoo[s], White-breasted Nuthatch, Summer Tanager[s], Great Horned Owl[r], Barred Owl[r], Red-shouldered Hawk[r], Broad-winged Hawk[s], Northern Bobwhite[r]
Old Field	12, 13, 14, 18, 22A, 36	Mourning Dove[s], Northern Flicker[r], Eastern Kingbird[s], Eastern Bluebird, American Robin[s], Northern Mockingbird[r], Brown Thrasher[s], Loggerhead Shrike[r], Common Yellowthroat[s], Yellow-breasted Chat[s], Indigo Bunting[s], Dickcissel[s], Field Sparrow[r], Eastern Meadowlark[s], Brown-headed Cowbird[r], Orchard Oriole[s], Northern Oriole[s], American Goldfinch[s], American Kestrel[r], Red-tailed Hawk[r], Northern Bobwhite[r]
Industrial Facilities	7, 7A, 8, 11, 11A, 14, 16, 18, 20	Same species as Old Field as well as Rock Dove[r], European Starling[r], House Sparrow[r]
Agricultural Fields	21, 35	Same species as Old Field would be found along the fence rows and field margins.

HABITAT TYPE	MAOU SITES THAT CONTAIN THE HABITAT TYPE	MAMMALS[c]
Deciduous Forest		
Upland Hardwood	7, 21	Virginia Opossum, Short Tail Shrew, Eastern Chipmunk, Eastern Cottontail, Gray Squirrel, Fox Squirrel, Southern Flying Squirrel, Gray Fox, Raccoon, Striped Skunk, Bobcat, White-tailed Deer
Bottomland Hardwood	9, 10, 27, 36	Species found in upland hardwoods as well as Least Shrew, Beaver, Cotton Mouse, Long-tailed Weasel, and Mink
Old Field	12, 13, 14, 18, 22A, 36	Virginia Opossum, Least Shrew, Eastern Mole, Eastern Cottontail, Woodchuck, Deer Mouse, Prairie Coyote, Red Fox, Gray Fox, Striped Skunk, and White-tailed Deer
Industrial Facilities	7, 7A, 8, 11, 11A, 14, 16, 18, 20	Same Species as Old Field Habitat Type
Agricultural Fields	21, 35	Same Species as Old Field Habitat Type would be found along the fence rows and field margins

HABITAT TYPE	MAOU SITES THAT CONTAIN THE HABITAT TYPE	HERPETOFAUNA[d]
Deciduous Forest		
Upland Hardwood	7, 21	American Toad, Western Chorus Frog, Five-lined Skink, Black Rat Snake, Ornate Bow Turtle, and Eastern Box Turtle
Bottomland Hardwood	9, 10, 27, 36	American Toad, Western Chorus Frog, Green Frog, Gray Treefrog, Bullfrog, Southern Leopard Frog, Eastern Garter Snake, Black Rat Snake, Eastern Painted Turtle, Ornate Box Turtle, Eastern Box Turtle
Old Field	12, 13, 14, 18, 22A, 36	American Toad, Western Chorus Frog, Southern Leopard Frog, Eastern Yellowbelly Racer, Eastern Hognose Snake, Prairie Kingsnake, and Eastern Garter Snake
Industrial Facilities	7, 71, 8, 11, 11A, 14, 16, 18, 20	Same as Old Field Habitat Type
Agricultural Fields	21, 35	Same species as Old Field Habitat Type would be found along the fence rows and field margins.

[a] Based on ESE 1993, Ulaszek 1988, and field observations.
[b] Based on ESE 1993, Urban 1981, checklist provided by Crab Orchard National Wildlife Refuge, and field observations.
[c] Based on ESE 1993, Schwartz and Schwartz 1974, species list provided by Crab Orchard National Wildlife Refuge, and field observations.
[d] Based on ESE 1993, Behler and King 1979, and field observations.
[s] Summer resident; bird breeds in the vicinity, but migrates south for the fall and winter.
[r] Bird breeds in the vicinity and is a year-round resident.

APPENDIX II

COMMON AND SCIENTIFIC NAMES OF SPECIES REFERENCED IN THE REPORT

APPENDIX II

COMMON AND SCIENTIFIC NAMES OF SPECIES REFERENCED IN THE REPORT

COMMON NAME	SCIENTIFIC NAME
AVIAN SPECIES	
Eastern Meadowlark	*Sturnella magna*
American Robin	*Turdus migratorius*
Eastern Bluebird	*Sialia sialis*
Northern Mockingbird	*Mimus polyglottos*
House Wren	*Troglodytes aedon*
Northern Cardinal	*Cardinalis cardinalis*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Great-crested Flycatcher	*Myiarchus crinitus*
Northern Bobwhite	*Colinus virginianus*
Red-winged Blackbird	*Agelaius phoeniceus*
Dickcissel	*Spiza americana*
Field Sparrow	*Spizella pusilla*
Yellow-breasted Chat	*Icteria virens*
Blue Jay	*Cyanocitta cristata*
Indigo Bunting	*Passerina cyanea*
Cedar Waxwing	*Bombycilla cedrorum*
Blue Grosbeak	*Guiraca caerulea*
Yellow-billed Cuckoo	*Coccyzus americanus*
European Starling	*Sturnus vulgaris*
Eastern Wood-peewee	*Contopus virens*
Eastern Phoebe	*Sayornis phoebe*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Downy Woodpecker	*Picoides pubescens*
Prothonotary Warbler	*Protonotaria citrea*
Louisiana Waterthrush	*Seiurus motacilla*
Northern Parula	*Parula americana*

COMMON NAME	SCIENTIFIC NAME
Red-eyed Vireo	*Vireo olivaceus*
Wood Thrush	*Hylocichla mustelina*
Common Grackle	*Quiscalus quiscula*
Brown-headed Cowbird	*Molothrus ater*
House Finch	*Carpodacus mexicanus*
American Goldfinch	*Carduelis tristis*
Orchard Oriole	*Icterus spurius*
Northern Oriole	*Icterus galbula*
Red-tailed Hawk	*Buteo jamaicensis*
Yellowthroat	*Geothlypis trichas*
Killdeer	*Charadrius vociferus*
Rock Dove	*Columba livia*
Mourning Dove	*Zenaida macroura*
Common Crow	*Corvus brachyrhynchos*
MAMMALS	
white-tailed deer	*Odocoileus virginianus*
eastern cottontail	*Sylvilagus floridanus*
eastern mole	*Scalopus aquaticus*
deer mouse	*Peromyscus maniculatus*
fox squirrel	*Sciurus niger*
gray squirrel	*Sciurus carolinensis*
prairie vole	*Microtus ochrogaster*
white-footed mouse	*Peromyscus leucopus*
racoon	*Procyon lotor*
coyote	*Canis latrans*
least shrew	*Cryptotis parva*
beaver	*Castor canadensis*

COMMON NAME	*SCIENTIFIC NAME*
AMPHIBIANS	
southern leopard frog	*Rana sphenocephala*
bullfrog	*Rana catesbeiana*
gray treefrog	*Hyla versicolor*
American toad	*Bufo americanus*
REPTILES	
prairie kingsnake	*Lampropeltis calligaster*
eastern garter snake	*Thamnophis sirtalis sirtalis*
eastern yellow-bellied racer	*Coluber constrictor flaviventris*
black rat snake	*Elaphe obsoleta obsoleta*
eastern box turtle	*Terrapene carolina*
eastern painted turtle	*Chrysemys picta picta*
northern water snake	*Nerodia sipedon*
five-lined skunk	*Eumeces faciatus*
SHRUB/TREES	
Black willow	*Salix nigra*
Red maple	*Acer rubrum*
Cottonwood	*Populus sp.*
Sycamore	*Acer pseudoplatanus*
Silver maple	*Acer saccharinum*
Scotch pine	*Pinus sylvestris*
Shortleaf pine	*Pinus echinata*
Loblolly pine	*Pinus taeda*
Black cherry	*Prunus serotina*
Staghorn sumac	*Rhus typhina*
Roughleaf dogwood	*Cornus rugosa*
White ash	*Fraxinus americana*

COMMON NAME	*SCIENTIFIC NAME*
Northern red oak	*Quercus rubra*
Pin oak	*Quercus palustris*
Overcup oak	*Quercus macrocarpa*
Swamp chesnut oak	*Quercus Michauxii*
Hickory sp.	*Carya sp.*
Eastern cottonwood	*Populus deltoides*
Elm	*Ulmus sp.*
Black locust	*Robinia pseudoacacia*
Honey locust	*Gleditsia tricanthos*
Sweet gum	*Liquidamber styraciflua*
Box elder	*Acer negundo*
Persimmon	*Diospyros sp.*
Sassafras	*Sassafras albidum*
Autumn olive	*Elaeagnus umbellata*
Multiflora rose	*Rosa multiflora*
Poison ivy	*Rhus radicans (Toxicodendron radicans)*
Mulberry	*Morus sp.*
Japanese honeysuckle	*Lonicera japonica*
Blackberry	*Rubus sp.*
Beggar's lice	*Hackelia sp.*
Coralberry	*Symphoricarpos orbiculatus*
Bramble	*Rupus sp.*
HERBACEOUS	
Fleabane (wild daisy)	*Erigeron sp.*
Goldenrod	*Solidago sp.*
Brome	*Bromus sp.*
Fescue	*Festuca sp.*

COMMON NAME	*SCIENTIFIC NAME*
Timothy	*Phleum sp.*
Bluegrass	*Poa sp.*
Nettle	*Urtica sp.*
Bulrush	*Scirpus sp.*
Cattails	*Typha sp.*
Yellow sweet clover	*Melilotus officinalis*
Day flower	*Commelina sp.*
Daisy	*Erigeron sp.*

APPENDIX III

EXPOSURE ANALYSIS ASSUMPTIONS

APPENDIX III

EXPOSURE ANALYSIS ASSUMPTIONS

AQUATIC LIFE

Fraction of organic carbon in sediments (f_{oc}): 0.6% for all sites. This parameter was not measured for soil and sediment samples collected in this study. However, O'Brien and Gere (1988) report average TOC values from background sites for soils in the refuge at 5809 mg/kg dry weight or 0.58% organic carbon.

Total organic carbon content of surface water (TOC): 20 mg/L for all sites. No information on organic carbon concentrations in surface water in the refuge were found. Average TOC levels in 500 Wiscousin Lakes are 17 mg/L (Wetzel 1983); a value of 20 mg/L was assumed for surface water at the study sites.

Dilution factor: 10X-100X. Water column concentration computed in Eq(5) are based on the assumption of equilibrium between contaminated soils or sediment (the media sampled at these site) and water. This might be the case for water in direct contact with those sediments, e.g., porewater or groundwater, but not for surface waters. At sites 7A, 11A, 12, 14, 16, 20, and 22A ("ponds") exposure of aquatic organisms to contaminated surface water would only occur during and following periods of heavy rain, when the contaminated areas would potentially flood and contaminants may be transported off-site to perennial streams or ponds. For these sites, a conservative estimate of dilution was set at 100:1 i.e., the ratio of uncontaminated to potentially contaminated water. At site 8, 9, 10, 11 and 36 samples were collected from sediments below permanent water bodies; a more conservative dilution factor of 10:1 was assumed for these sites.

SITE 22A

For exposure concentrations and doses of dioxins/furans, all calculations were based on 2, 3, 7, 8 - TCDD equivalents; thus, *ERI*'s for dioxin/furan were based on toxicity of 2, 3, 7, 8 - TCDD:

Compound	TEF*	Measured Concentrations (μg/kg)										
		22A01	22A02	22A03	22A03	22A04	22A07	22A08	22A13	22A10	22A10	22A11
2,3,7,8-TCDD	1	0	0	0	0	0	0	0	0	0	0	0
1,2,3,7,8-PeCDD	0.5	0	0	0	0	0	0	0	0	0	0	0
1,2,3,4,7,8-HxCDD	0.1	0	0	0.469	0	0	0	0	0	0	0	0
1,2,3,6,7,8-HxCDD	0.1	0	0	1.73	0.413	0	0	0	0	0.464	0.177	0.197
1,2,3,7,8,9-HxCDD	0.1	0	0	0	0	0	0	0	0	0.24	0	0
1,2,3,4,6,7,8-HpCDD	0.1	0.434	0	63	23.8	2.88	9.52	3.65	3.65	12.7	7.43	7.66
OCDD	0.001	9.01	7.63	600	164	31.8	103	45.5	39.8	91	47.4	69.8
2,3,7,8-TCDF	0.1	0	0	0	0	0	0	0	0	0	0	0
1,2,3,7,8-PeCDF	0.05	0	0	0	0	0	0	0	0	0	0	0
2,3,4,7,8-PeCDF	0.5	0	0	0	0.144	0	0	0	0	0	0	0
1,2,3,4,7,8-HxCDF	0.1	0	0	0.376	0	0	0	0	0	0	0	0
1,2,3,6,7,8-HxCDF	0.1	0	0	5.22	1.48	0	0.518	0	0	0.751	0.456	0.318
2,3,4,6,7,8-HxCDF	0.1	0	0	0.228	0	0	0	0	0	0	0	0
1,2,3,7,8,9-HxCDF	0.1	0	0	0	0	0	0	0	0	0	0	0
1,2,3,4,6,7,8-HpCDF	0.1	0	0	17	0	0.836	1.85	0.729	0.694	0	0	1.45
1,2,3,4,7,8,9-HpCDF	0.01	0	0	1.04	0	0	0	0	0	0	0	0
OCDF	0.001	0	0	89.3	23.3	5.79	8.39	3.45	3.31	8.12	3.64	4.74

Compound	TEF*	2,3,7,8-TCDD Equivalents (µg/kg)										
		22A01	22A02	22A03	22A03	22A04	22A07	22A08	22A13	22A10	22A10	22A11
2,3,7,8-TCDD	1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1,2,3,7,8-PeCDD	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1,2,3,4,7,8-HxCDD	0.1	0.000	0.000	0.047	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1,2,3,6,7,8-HxCDD	0.1	0.000	0.000	0.173	0.041	0.000	0.000	0.000	0.000	0.046	0.018	0.020
1,2,3,7,8,9-HxCDD	0.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.000	0.000
1,2,3,4,6,7,8-HpCDD	0.1	0.043	0.000	6.300	2.380	0.288	0.952	0.365	0.365	1.270	0.743	0.766
OCDD	0.001	0.009	0.008	0.600	0.164	0.032	0.103	0.046	0.040	0.091	0.047	0.070
2,3,7,8-TCDF	0.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1,2,3,7,8-PeCDF	0.5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2,3,4,7,8-PeCDF	0.5	0.000	0.000	0.000	0.057	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1,2,3,4,7,8-HxCDF	0.1	0.000	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1,2,3,6,7,8-HxCDF	0.1	0.000	0.000	0.522	0.148	0.000	0.052	0.000	0.000	0.075	0.046	0.032
2,3,4,6,7,8-HxCDF	0.1	0.000	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1,2,3,7,8,9-HxCDF	0.1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1,2,3,4,6,7,8-HpCDF	0.1	0.000	0.000	1.700	0.000	0.084	0.185	0.073	0.069	0.000	0.000	0.145
1,2,3,4,7,8,9-HpCDF	0.01	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OCDF	0.001	0.000	0.000	0.089	0.023	0.006	0.008	0.003	0.003	0.008	0.004	0.005
TOTAL TEF:	-	0.052	0.008	9.502	2.814	0.409	1.300	0.487	0.478	1.515	0.857	1.037

*TEFs (Toxicity Equivalent Factors) based on NATO International Toxicity Equivalency Factors (CCME 1991)

ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR WHITE-TAILED DEER

Body Weight: 60 kg for an adult female (average value derived from weights reported in Halls 1978 and Sauer 1984).

Food Ingestion Rate: 1.8 kg/day dry weight. Daily dry matter consumption for deer is approximately 2-4% of live body weight (Halls 1978). Therefore, we chose 3% as the average value.
60kg x 0.03 = 1.8 kg/day

Fraction of Food Derived From Site: 100%. The home range of female deer in this region of the country is reported to average 160 ha (Progulske and Baskett 1958) and all sites were considerably smaller, thus, over the long-term deer would acquire only a small fraction of their food from any one site. However, over the short term, e.g., a one-day period, we assumed a worst-case scenario that all of their food was aquired from the site.

Water Ingestion Rate: 4.0 litres/day. Lautier et al. (1988) reported that deer with an average weight of 54 kg consumed an average of 3.6 litres of water a day while on a dry, pelleted diet. Assuming a linear conversion, a 60 kg deer should consume 4.0 litres/day.

Nichols (1936) reported that the conversion factor for deer feeding on succulent browse should yield a 50% reduction in water intake per day. Nonetheless, we used 4.0 litres/day as a conservative estimate of average daily water intake.

Fraction of Water Derived From Site: 100%. We assumed a worst-case scenario where, over short-time periods, all water was consumed from the sites.

Soil Ingestion Rate: 16 g/day dry weight (from Weston 1989 as reported by ESE 1993).

ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR RACCOON

Body Weight: 6.0 kg for an adult female (Sanderson 1987).

Food Ingestion Rate: 400 g/day, dry weight. No food ingestion rates were found in the literature. Therefore, we used the equations:

$$BMR = 70W^{0.75} = 268 \text{ kcal/day}$$

$$DEE = 3 \times BMR = 805 \text{ kcal/day}$$

to estimate daily energy expenditure. Where BMR = Basal metabolic rate, W = body weight in kg, and DEE = Daily energy expenditure (from Robbins 1983). We assumed a conservative metabolizable energy (ME) of 2.0 kcal/g of food ingested. Therefore, total food intake should be approximately 400 g/day to maintain body weight.

Fraction of Food Derived From Site: 100 g/day dry weight of aquatic-based foods. We assumed that crayfish, frogs and fish average 25% of the raccoon's diet in the area (Sanderson 1987). We further assumed that raccoons were consuming 100% of their total daily intake of crayfish, frogs and fish from the site per day. Raccoon home ranges are reported to range from 40 - 100 ha (Sanderson 1987). Because the sites were all considerably smaller, over the long-term only a small fraction of their food would be derived from any one site. However, over short-term periods, we assumed a worst-case scenario in which all of their food was acquired from the sites.

Therefore, total intake from the sites was approximated at 400 g/day x 0.25 x 1.0 = 100 g/d.

Water Ingestion Rate: 0.3/L days. We could not find any literature on water ingestion rates for raccoons. Therefore we chose 5% of their body weight per day as a conservative estimate; i.e., they probably consume less.

Fraction of Water Derived From Site: 100%. We assumed a worst-case scenario where, over short-time periods, all of their water was consumed from the sites.

Soil Ingestion Rate: 5 g/day dry weight. Conservative estimate based on 10% of food ingestion from the site.

ECOLOGICAL AND PHYSIOLOGICAL ASSUMPTIONS FOR AMERICAN ROBIN

Body Weight:	80 g (Wheelwright 1986).
Food Ingestion Rate:	70 g of earthworms per day, wet weight. Estimate based on a published report of American Robins consuming 6.8 g (dry weight) of crickets per day (Levey and Karasov 1989). A conservative wet weight conversion for earthworms was obtained by multiplying dry weight by 10 (Wetzel 1983). Therefore, 6.8 x 10 = 68 grams/day, which we rounded up to 70 grams per day.
Fraction of Food Derived From Site:	100%. Arguably, the entire site could comprise the feeding territory for resident birds.
Water Ingestion Rate:	8 mL/day. Conservative estimate based on 10% body weight.
Fraction of Water Derived From Site:	100%. We assumed a worst-case scenario in which all water was acquired on site.
Soil Ingestion Rate:	2 g/day dry weight. We assumed that soils comprised 25% of the dry weight of earthworms consumed on the site. We believe this is a conservative estimate.

APPENDIX IV

EXPOSURE CALCULATIONS

Site	Parameter	Csoil [mg/kg] maximum recorded	Koc log Eq(3)	kd log Eq(2)	Cdiss [mg/L] Eq(1)	Coc [mg/L] Eq(4)	Cwc [mg/L] Eq(5)	Dilution Factor (DF) App.III	Diluted C(WC) [mg/L] DF*Cwc	Cplant [mg/kg] Eq(6)	Canimal [mg/kg] Eq(7)	Cair [mg/L] Eq(12)
Background	antimony	2.01	-	0.000	2.01E+00	0.00E+00	2.01E+00	100	2.01E-02	2.01E+02	6.36E+02	-
Background	arsenic	11.83	-	-1.000	1.18E+02	0.00E+00	1.18E+02	100	1.18E+00	5.93E+03	3.74E+04	-
Background	cadmium	0.75	-	0.000	7.50E-01	0.00E+00	7.50E-01	100	7.50E-03	3.76E+02	5.96E+02	-
Background	chromium	57.38	-	0.000	5.74E+01	0.00E+00	5.74E+01	100	5.74E-01	2.88E+04	1.15E+04	-
Background	copper	20.89	-	0.000	2.09E+01	0.00E+00	2.09E+01	100	2.09E-01	2.09E+04	4.17E+03	-
Background	lead	21.27	-	0.000	2.13E+01	0.00E+00	2.13E+01	100	2.13E-01	4.25E+04	1.34E+05	-
Background	manganese	1080	-	0.000	1.08E+03	0.00E+00	1.08E+03	100	1.08E+01	1.08E+08	1.08E+05	-
Background	mercury	0.06	-	0.000	6.00E-02	1.20E-06	6.00E-02	100	6.00E-04	1.90E+02	1.90E+02	-
Background	nickel	26.55	-	0.000	2.66E+01	0.00E+00	2.66E+01	100	2.66E-01	2.66E+03	2.66E+03	-
Background	silver	0.77	-	0.000	7.70E-01	0.00E+00	7.70E-01	100	7.70E-03	1.54E+02	2.44E+03	-
Background	zinc	120	-	0.000	1.20E+02	2.40E-03	1.20E+02	100	1.20E+00	4.78E+05	2.39E+05	-
8	methylethyl ketone	0.06	0.699	-1.523	2.00E+00	2.00E-04	2.00E+00	10	2.00E-01	1.58E+00	1.96E+00	3.32E-03
9	silver	1.7	-	0.000	1.70E+00	0.00E+00	1.70E+00	10	1.70E-01	3.39E+02	5.38E+03	-
10	methylethyl ketone	0.02	0.699	-1.523	6.67E-01	6.67E-05	6.67E-01	10	6.67E-02	5.26E-01	6.52E-01	1.11E-03
10	phenanthrene	0.45	3.701	1.479	1.49E-02	1.50E-03	1.64E-02	10	1.64E-03	4.60E-02	2.92E+01	-
10	fluoranthene	0.69	4.054	1.832	1.02E-02	2.30E-03	1.25E-02	10	1.25E-03	3.71E-02	4.96E+01	-
10	pyrene	0.51	4.004	1.782	8.43E-03	1.70E-03	1.01E-02	10	1.01E-03	3.00E-02	2.73E+01	-
10	cadmium	0.76	-	0.000	7.60E-01	0.00E+00	7.60E-01	10	7.60E-02	3.81E+02	6.04E+02	-
10	silver	1.24	-	0.000	1.24E+00	0.00E+00	1.24E+00	10	1.24E-01	2.47E+02	3.92E+03	-
10	benzo(a)anthracene	0.25	4.565	2.343	1.13E-03	8.33E-04	1.97E-03	10	1.97E-04	5.22E-03	6.82E-01	-
10	benzo(b)fluoranthene	0.34	4.896	2.675	7.19E-04	1.13E-03	1.85E-03	10	1.85E-04	3.81E-03	4.44E+01	-
11	arsenic	15	-	-1.000	1.50E+02	0.00E+00	1.50E+02	10	1.50E+01	7.52E+03	4.74E+04	-
11	silver	1.6	-	0.000	1.60E+00	0.00E+00	1.60E+00	10	1.60E-01	3.19E+02	5.06E+03	-
11A	acetone	0.52	0.317	-1.905	4.17E+01	1.73E-03	4.18E+01	100	4.18E-01	2.79E+01	1.62E+01	-
11A	methylethyl ketone	0.014	0.699	-1.523	4.67E-01	4.67E-05	4.67E-01	100	4.67E-03	3.68E-01	4.56E-01	7.74E-04
11A	2,4,6-trinitrotoluene	0.38	-	-0.580	1.44E+00	0.00E+00	1.44E+00	100	1.45E-02	1.74E+00	5.89E+01	-
11A	silver	1.8	-	0.000	1.80E+00	0.00E+00	1.80E+00	100	1.80E-02	3.59E+02	5.69E+03	-
12	acetone	1.7	0.317	-1.905	1.36E+02	5.67E-03	1.36E+02	100	1.36E+00	9.13E+01	5.31E+01	-
12	methylethyl ketone	0.007	0.699	-1.523	2.33E-01	2.33E-05	2.33E-01	100	2.33E-03	1.84E-01	2.28E-01	3.87E-04
12	phenanthrene	0.32	3.701	1.479	1.06E-02	1.07E-03	1.17E-02	100	1.17E-04	3.27E-02	2.08E+01	-
12	pyrene	0.42	4.004	1.782	6.94E-03	1.40E-03	8.34E-03	100	8.34E-05	2.47E-02	2.25E+01	-
12	silver	1.3	-	0.000	1.30E+00	0.00E+00	1.30E+00	100	1.30E-02	2.59E+02	4.11E+03	-
14	ethylbenzene	11.3	2.758	0.536	3.29E+00	3.77E-02	3.33E+00	100	3.33E-02	6.65E+00	5.03E+01	1.07E+00
14	m-xylene	28	2.794	0.572	7.50E+00	9.33E-02	7.59E+00	100	7.59E-02	1.54E+01	1.15E+02	2.21E+00
14	o-xylene	4.6	2.736	0.515	1.41E+00	1.53E-02	1.42E+00	100	1.42E-02	2.77E+00	2.01E+02	2.98E-01
14	p-xylene	28	2.758	0.536	8.15E+00	9.33E-02	8.24E+00	100	8.24E-02	1.65E+01	1.25E+02	2.17E+00
14	methylene chloride	0.21	1.390	-0.832	1.43E+00	7.00E-04	1.43E+00	100	1.43E-02	1.56E+00	7.49E+00	2.17E-01
14	methylethyl ketone	0.007	0.699	-1.523	2.33E-01	2.33E-05	2.33E-01	100	2.33E-03	1.84E-01	2.28E-01	3.87E-04
14	cyanide	4.3	-	-1.000	4.30E+01	8.60E-04	4.30E+01	100	4.30E-01	4.30E+01	4.30E+02	-
14	lead	150	-	0.000	1.50E+02	0.00E+00	1.50E+02	100	1.50E+00	2.99E+05	9.46E+05	-
14	mercury	0.26	-	0.000	2.60E-01	0.00E+00	2.60E-01	100	2.60E-03	8.22E+02	8.22E+02	-
14	cadmium	0.94	-	0.000	9.40E-01	0.00E+00	9.40E-01	100	9.40E-03	4.71E+02	7.47E+02	-
14	chromium	60	-	0.000	6.00E+01	0.00E+00	6.00E+01	100	6.00E-01	3.01E+04	1.20E+04	-
14	copper	23	-	0.000	2.30E+01	0.00E+00	2.30E+01	100	2.30E-01	2.30E+04	4.59E+03	-
14	manganese	1800	-	0.000	1.80E+03	0.00E+00	1.80E+03	100	1.80E+01	1.80E+08	1.80E+05	-
14	silver	2.4	-	0.000	2.40E+00	0.00E+00	2.40E+00	100	2.40E-02	4.79E+02	7.59E+03	-
16	aroclor-1254	103	5.148	2.927	1.22E-01	3.43E-01	4.65E-01	100	4.65E-03	1.75E+00	1.47E+05	-
16	aroclor-1260	61	5.148	2.927	7.22E-02	2.03E-01	2.76E-01	100	2.76E-03	4.32E-01	6.92E+04	-
16	cadmium	0.9	-	0.000	9.00E-01	0.00E+00	9.00E-01	100	9.00E-03	4.51E+02	7.15E+02	-
16	copper	35	-	0.000	3.50E+01	0.00E+00	3.50E+01	100	3.50E-01	3.50E+04	6.98E+03	-
16	silver	1.18	-	0.000	1.18E+00	0.00E+00	1.18E+00	100	1.18E-02	2.35E+02	3.73E+03	-
20	lead	50	-	0.000	5.00E+01	0.00E+00	5.00E+01	100	5.00E-01	9.98E+04	3.15E+05	-
20	silver	1.5	-	0.000	1.50E+00	0.00E+00	1.50E+00	100	1.50E-02	2.99E+02	4.74E+03	-
22A	benzo(a)anthracene	0.55	4.565	2.343	2.49E-03	1.83E-03	4.33E-03	100	4.33E-05	1.15E-02	1.50E+00	-
22A	benzo(a)pyrene	0.39	4.788	2.567	1.06E-03	1.30E-03	2.36E-03	100	2.36E-05	2.19E-02	2.15E+00	-
22A	benzo(b)fluoranthene	0.72	4.896	2.675	1.52E-03	2.40E-03	3.92E-03	100	3.92E-05	8.08E-03	9.41E+01	-
22A	chrysene	0.63	4.565	2.343	2.86E-03	2.10E-03	4.96E-03	100	4.96E-05	1.32E-02	5.82E+01	-
22A	2,3,7,8-TCDD	0.0095	4.918	2.696	1.91E-05	3.17E-05	5.08E-05	100	5.08E-07	1.28E-04	6.39E+00	-

Site	Parameter	Csoil [mg/kg] maximum recorded	Koc log Eq(3)	kd log Eq(2)	Cdiss [mg/L] Eq(1)	Coc [mg/L] Eq(4)	Cwc [mg/L] Eq(5)	Dilution Factor (DF) App.III	Diluted C(WC) [mg/L] DF*Cwc	Cplant [mg/kg] Eq(6)	Canimal [mg/kg] Eq(7)	Cair [mg/L] Eq(12)
22A	pentachlorophenol	3.2	4.176	1.955	3.55E-02	1.07E-02	4.62E-02	100	4.62E-04	1.37E-01	3.59E+01	-
22A	methylene chloride	0.065	1.390	-0.832	4.41E-01	2.17E-04	4.42E-01	100	4.42E-03	4.82E-01	2.32E+00	6.72E-02
22A	methylethyl ketone	0.005	0.699	-1.523	1.67E-01	1.67E-05	1.67E-01	100	1.67E-03	1.32E-01	1.63E-01	2.76E-04
22A	phenanthrene	0.21	3.701	1.479	6.96E-03	7.00E-04	7.66E-03	100	7.66E-05	2.15E-02	1.36E+01	-
22A	anthracene	0.2	3.694	1.472	6.74E-03	6.67E-04	7.41E-03	100	7.41E-05	2.08E-02	1.00E+01	-
22A	pyrene	0.59	4.004	1.782	9.75E-03	1.97E-03	1.17E-02	100	1.17E-04	3.47E-02	3.15E+01	-
22A	DDD	0.0121	4.824	2.603	3.02E-05	4.03E-05	7.05E-05	100	7.05E-07	1.56E-04	5.60E+00	-
22A	DDE	0.027	4.587	2.365	1.17E-04	9.00E-05	2.07E-04	100	2.07E-06	2.83E-03	1.68E+01	-
22A	DDT	0.036	5.069	2.847	5.12E-05	1.20E-04	1.71E-04	100	1.71E-06	5.71E-04	1.60E+01	-
22A	mercury	0.26	-	0.000	2.60E-01	0.00E+00	2.60E-01	100	2.60E-03	8.22E+02	8.22E+02	-
22A	cadmium	1.04	-	0.000	1.04E+00	0.00E+00	1.04E+00	100	1.04E-02	5.21E+02	8.26E+02	-
22A	manganese	1600	-	0.000	1.60E+03	0.00E+00	1.60E+03	100	1.60E+01	1.60E+08	1.60E+05	-
22A	silver	1.6	-	0.000	1.60E+00	0.00E+00	1.60E+00	100	1.60E-02	3.19E+02	5.06E+03	-
36-Dove Cr.	aldrin	0.77	4.464	2.243	4.40E-03	2.57E-03	6.97E-03	10	6.97E-04	1.65E-02	2.20E+01	-
36-Dove Cr.	aroclor-1248	8.9	5.148	2.927	1.05E-02	2.97E-02	4.02E-02	10	4.02E-03	6.30E-02	5.06E+03	-
36-Dove Cr.	aroclor-1254	8.2	5.148	2.927	9 71E-03	2.73E-02	3.70E-02	10	3.70E-03	1.39E-01	1.17E+04	-
36-Dove Cr.	aroclor-1260	0.95	5.148	2.927	1 13E-03	3.17E-03	4.29E-03	10	4.29E-04	6.73E-03	1.08E+03	-
36-Dove Cr.	cadmium	24	-	0.000	2.40E+01	0.00E+00	2.40E+01	10	2.40E+00	1.20E+04	1.91E+04	-
36-Dove Cr.	copper	37	-	0.000	3.70E+01	0.00E+00	3.70E+01	10	3 70E+00	3.70E+04	7.38E+03	-
36-Dove Cr.	lead	61	-	0.000	6.10E+01	0.00E+00	6.10E+01	10	6.10E+00	1.22E+05	3.85E+05	-
36-Dove Cr.	mercury	0.26	-	0.000	2.60E-01	0.00E+00	2.60E-01	10	2.60E-02	8 22E+02	8 22E+02	-
36-Dove Cr.	silver	1.7	-	0.000	1.70E+00	0.00E+00	1.70E+00	10	1 70E-01	3.39E+02	5.38E+03	-
36-Dove Cr.	zinc	158	-	0.000	1.58E+02	0.00E+00	1.58E+02	10	1.58E+01	6.29E+05	3.15E+05	-
36-West Pond	cadmium	6	-	0.000	6.00E+00	0.00E+00	6.00E+00	10	6.00E-01	3.01E+03	4.77E+03	-
36-West Pond	silver	1.7	-	0.000	1.70E+00	0.00E+00	1.70E+00	10	1 70E-01	3.39E+02	5.38E+03	-
36-Lagoon	acetone	0.68	0.317	-1.905	5.46E+01	2.27E-03	5.46E+01	10	5.46E+00	3.65E+01	2.12E+01	-
36-Lagoon	aroclor-1248	0.15	5.148	2.927	1.78E-04	5.00E-04	6.78E-04	10	6 78E-05	1.06E-03	8.53E+01	-
36-Lagoon	aroclor-1254	0.18	5.148	2.927	2.13E-04	6.00E-04	8.13E-04	10	8.13E-05	3.06E-03	2.57E+02	-
36-East Pond	methylene chloride	0.8	1.390	-0.832	5.43E+00	2.67E-03	5.43E+00	10	5.43E-01	5.93E+00	2.85E+01	8.27E-01
36-East Pond	acetone	0.88	0.317	-1.905	7.07E+01	2.93E-03	7.07E+01	10	7.07E+00	4.73E+01	2.75E+01	-
36-East Pond	methylethyl ketone	0.161	0.699	-1.523	5.37E+00	5.37E-04	5.37E+00	10	5.37E-01	4.23E+00	5.25E+00	8.90E-03
36-East Pond	mercury	3	-	0.000	3.00E+00	0.00E+00	3.00E+00	10	3.00E-01	9.49E+03	9.49E+03	-
36-East Pond	chromium	200	-	0.000	2.00E+02	0.00E+00	2.00E+02	10	2.00E+01	1.00E+05	3.99E+04	-
36-East Pond	copper	158	-	0.000	1.58E+02	0.00E+00	1.58E+02	10	1.58E+01	1.58E+05	3.15E+04	-
36-East Pond	manganese	1300	-	0.000	1.30E+03	0.00E+00	1.30E+03	10	1.30E+02	1.30E+08	1.30E+05	-
36-East Pond	nickel	36	-	0.000	3 60E+01	0 00E+00	3.60E+01	10	3.60E+00	3.60E+03	3.60E+03	-
36-East Pond	silver	108	-	0.000	1.08E+02	0.00E+00	1.08E+02	10	1.08E+01	2.15E+04	3.42E+05	-
36-East Pond	zinc	800	-	0.000	8.00E+02	0.00E+00	8.00E+02	10	8.00E+01	3.18E+06	1.60E+06	-
36-East Pond	2-methylnaphthalene	18.9	3.269	1.047	1.69E+00	6.30E-02	1.76E+00	10	1.76E-01	4.33E+00	1.72E+02	-
36-East Pond	acenaphthene	28	3.312	1.091	2.27E+00	9.33E-02	2.37E+00	10	2.37E-01	5.85E+00	9.21E+02	-
36-East Pond	aldrin	3.3	4.464	2.243	1.89E-02	1 10E-02	2.99E-02	10	2.99E-03	7.06E-02	9.45E+01	-
36-East Pond	anthracene	9.4	-	1.472	3.17E-01	0 00E+00	3.17E-01	10	3.48E-02	9.77E-01	4.70E+02	-
36-East Pond	antimony	39	-	0.000	3.90E+01	0 00E+00	3.90E+01	10	3.90E+00	3.90E+03	1.23E+04	-
36-East Pond	aroclor-1248	42	5.148	2.927	4.97E-02	1 40E-01	1.90E-01	10	1.90E-02	2 97E-01	2.39E+04	-
36-East Pond	aroclor-1254	80	5.148	2.927	9.47E-02	2.67E-01	3.61E-01	10	3.61E-02	1 36E+00	1.14E+05	-
36-East Pond	aroclor-1260	7.8	5.148	2.927	9.24E-03	2.60E-02	3.52E-02	10	3.52E-03	5 52E-02	8.85E+03	-
36-East Pond	benzo(a)anthracene	3.9	4.565	2.343	1.77E-02	1.30E-02	3.07E-02	10	3.07E-03	8.15E-02	1.06E+01	-
36-East Pond	benzo(a)pyrene	1.44	4.788	2.567	3.91E-03	4.80E-03	8.71E-03	10	8.71E-04	8.10E-02	7.94E+00	-
36-East Pond	benzo(b)fluoranthene	3.9	4.896	2.675	8.25E-03	1.30E-02	2.13E-02	10	2.13E-03	4.38E-02	5.10E+02	-
36-East Pond	bis(2-ethylhexyl)phthalate	1.22	4.169	1.947	1.38E-02	4.07E-03	1.78E-02	10	1.78E-03	5.20E-02	2.41E+02	-
36-East Pond	cadmium	27	-	0.000	2.70E+01	0.00E+00	2.70E+01	10	2.70E+00	1.35E+04	2.14E+04	-
36-East Pond	chrysene	2.61	4.565	2.343	1.18E-02	8.70E-03	2.05E-02	10	2.05E-03	5.45E-02	2.41E+02	-
36-East Pond	dibenzofuran	19.7	3.456	1.235	1.15E+00	6.57E-02	1.21E+00	10	1.21E-01	3.19E+00	1.64E+03	-
36-East Pond	fluoranthene	24.2	4.054	1.832	3.56E-01	8.07E-02	4.37E-01	10	4.37E-02	1.30E+00	1.74E+03	-
36-East Pond	fluorene	44	3.500	1.278	2.32E+00	1.47E-01	2.47E+00	10	2.47E-01	6.51E+00	3 18E+03	-
36-East Pond	lead	500	-	0.000	5.00E+02	0.00E+00	5.00E+02	10	5.00E+01	9.98E+05	3 15E+06	-
36-East Pond	naphthalene	6.1	2.866	0.644	1.38E-00	2.03E-02	1.40E+00	10	1.40E-01	2.92E+00	5 99E+02	-
36-East Pond	phenanthrene	50	3.701	1.479	1.66E+00	1.67E-01	1.82E+00	10	1.82E-01	5.12E+00	3.24E+03	-
36-East Pond	pyrene	13.9	4.004	1.782	2.30E-01	4.63E-02	2.76E-01	10	2.76E-02	8.18E-01	7.43E+02	-

Site	Parameter	White-Tailed Deer EDIsoil [mg/kg-B Eq(9)	EDIwater [mg/kg-B Eq(10)	EDIfood [mg/kg-B Eq(11)	TDI Eq(8)	American Robin EDIsoil [mg/kg-BW Eq(9)	EDIwater [mg/kg-B Eq(10)	EDIfood [mg/kg-BW Eq(11)	TDI Eq(8)	Raccoons EDIsoil [mg/kg-B Eq(9)	EDIwater [mg/kg-B Eq(10)	EDIfood [mg/kg-BW Eq(11)	TDI Eq(8)
Background	antimony	5.36E-04	1.34E-03	6.03E+00	6.03E+00	5.03E-02	2.01E-03	5.57E+02	5.57E+02	1.68E-03	1.01E-03	1.06E+01	1.06E+01
Background	arsenic	3.15E-03	7.89E-02	1.78E+02	1.78E+02	2.96E-01	1.18E-01	3.27E+04	3.27E+04	9.86E-03	5.92E-02	6.23E+02	6.23E+02
Background	cadmium	2.00E-04	5.00E-04	9.03E+01	9.03E+01	1.88E-02	7.50E-04	4.17E+03	4.17E+03	6.25E-04	3.75E-04	9.93E+00	9.93E+00
Background	chromium	1.53E-02	3.83E-02	8.64E+02	8.64E+02	1.43E+00	5.74E-02	1.01E+04	1.01E+04	4.78E-02	2.87E-02	1.92E+02	1.92E+02
Background	copper	5.57E-03	1.39E-02	6.27E+02	6.27E+02	5.22E-01	2.09E-02	3.65E+03	3.65E+03	1.74E-02	1.04E-02	6.95E+01	6.95E+01
Background	lead	5.67E-03	1.42E-02	1.28E+03	1.28E+03	5.32E-01	2.13E-02	1.17E+05	1.17E+05	1.77E-02	1.06E-02	2.23E+03	2.23E+03
Background	manganese	2.88E-01	7.20E-01	3.24E+06	3.24E+06	2.70E+01	1.08E+00	9.45E+04	9.45E+04	9.00E-01	5.40E-01	1.80E+03	1.80E+03
Background	mercury	1.60E-05	4.00E-05	5.70E+00	5.70E+00	1.50E-03	6.00E-05	1.66E+02	1.66E+02	5.00E-05	3.00E-05	3.17E+00	3.17E+00
Background	nickel	7.08E-03	1.77E-02	7.98E+01	7.98E+01	6.64E-01	2.66E-02	2.33E+03	2.33E+03	2.21E-02	1.33E-02	4.43E+01	4.44E+01
Background	silver	2.05E-04	5.13E-04	4.62E+00	4.62E+00	1.93E-02	7.70E-04	2.14E+03	2.14E+03	6.42E-04	3.85E-04	4.07E+01	4.07E+01
Background	zinc	3.20E-02	8.00E-02	1.43E+04	1.43E+04	3.00E+00	1.20E-01	2.10E+05	2.10E+05	1.00E-01	6.00E-02	3.99E+03	3.99E+03
8	methylethyl ketone	1.60E-05	1.33E-02	4.73E-02	6.07E-02	-	-	-	-	5.00E-05	1.00E-02	3.26E-02	4.26E-02
9	silver	4.53E-04	1.13E-02	1.02E+01	1.02E+01	-	-	-	-	1.42E-03	8.50E-03	8.96E+01	8.96E+01
10	methylethyl ketone	5.33E-06	4.45E-03	1.58E-02	2.02E-02	-	-	-	-	1.67E-05	3.33E-03	1.09E-02	1.42E-02
10	phenanthrene	1.20E-04	1.09E-04	1.38E-03	1.61E-03	-	-	-	-	3.75E-04	8.21E-05	4.87E-01	4.87E-01
10	fluoranthene	1.84E-04	8.30E-05	1.11E-03	1.38E-03	-	-	-	-	5.75E-04	6.23E-05	8.26E-01	8.27E-01
10	pyrene	1.36E-04	6.75E-05	9.01E-04	1.10E-03	-	-	-	-	4.25E-04	5.06E-05	4.54E-01	4.55E-01
10	cadmium	2.03E-04	5.07E-03	1.14E+01	1.14E+01	-	-	-	-	6.33E-04	3.80E-03	1.01E+01	1.01E+01
10	silver	3.31E-04	8.27E-03	7.42E+00	7.43E+00	-	-	-	-	1.03E-03	6.20E-03	6.54E+01	6.54E+01
10	benzo(a)anthracene	6.67E-05	1.31E-05	1.57E-04	2.36E-04	-	-	-	-	2.08E-04	9.84E-06	1.14E-02	1.16E-02
10	benzo(b)fluoranthene	9.07E-05	1.24E-05	1.14E-04	2.17E-04	-	-	-	-	2.83E-04	9.26E-06	7.41E-01	7.41E-01
11	arsenic	4.00E-03	1.00E+00	2.26E+02	2.27E+02	3.75E-01	1.50E+00	4.15E+04	6.58E+03	-	-	-	-
11	silver	4.27E-04	1.07E-02	9.58E+00	9.59E+00	4.00E-02	1.60E-02	4.43E+03	2.79E+02	-	-	-	-
11A	acetone	1.39E-04	2.78E-02	8.38E-01	8.66E-01	1.30E-02	4.18E-02	1.42E+01	2.45E+01	-	-	-	-
11A	methylethyl ketone	3.73E-06	3.11E-04	1.10E-02	1.14E-02	3.50E-04	4.67E-04	3.99E-01	3.23E-01	-	-	-	-
11A	2,4,6-trinitrotoluene	1.01E-04	9.64E-04	5.21E-02	5.32E-02	9.50E-03	1.45E-03	5.15E+01	1.53E+00	-	-	-	-
11A	silver	4.80E-04	1.20E-03	1.08E+01	1.08E+01	4.50E-02	1.80E-03	4.98E+03	3.14E+02	-	-	-	-
12	acetone	4.53E-04	9.10E-02	2.74E+00	2.83E+00	4.25E-02	1.36E-01	4.65E+01	8.01E+01	-	-	-	-
12	methylethyl ketone	1.87E-06	1.56E-04	5.52E-03	5.68E-03	1.75E-04	2.33E-04	2.00E-01	1.62E-01	-	-	-	-
12	phenanthrene	8.53E-05	7.79E-06	9.82E-04	1.08E-03	8.00E-03	1.17E-05	1.82E+01	3.67E-02	-	-	-	-
12	pyrene	1.12E-04	5.56E-06	7.42E-04	8.60E-04	1.05E-02	8.34E-06	1.96E+01	3.21E-02	-	-	-	-
12	silver	3.47E-04	8.67E-04	7.78E+00	7.78E+00	3.25E-02	1.30E-03	3.60E+03	2.27E+02	-	-	-	-
14	ethylbenzene	3.01E-03	2.22E-03	2.00E-01	2.05E-01	2.83E-01	3.33E-03	4.40E+01	6.11E+00	-	-	-	-
14	m-xylene	7.47E-03	5.06E-03	4.62E-01	4.74E-01	7.00E-01	7.59E-03	1.01E+02	1.42E+01	-	-	-	-
14	o-xylene	1.23E-03	9.48E-04	8.32E-02	8.53E-02	1.15E-01	1.42E-03	1.76E+02	2.54E+00	-	-	-	-
14	p-xylene	7.47E-03	5.49E-03	4.95E-01	5.08E-01	7.00E-01	8.24E-03	1.09E+02	1.51E+01	-	-	-	-
14	methylene chloride	5.60E-05	9.51E-04	4.67E-02	4.77E-02	5.25E-03	1.43E-03	6.55E+00	1.37E+00	-	-	-	-
14	methylethyl ketone	1.87E-06	1.56E-04	5.52E-03	5.68E-03	1.75E-04	2.33E-04	2.00E-01	1.62E-01	-	-	-	-
14	cyanide	1.15E-03	2.87E-02	1.29E+00	1.32E+00	1.08E-01	4.30E-02	3.76E+02	3.78E+01	-	-	-	-
14	lead	4.00E-02	1.00E-01	8.98E+03	8.98E+03	3.75E+00	1.50E-01	8.28E+05	2.62E+05	-	-	-	-
14	mercury	6.93E-05	1.73E-04	2.47E+01	2.47E+01	6.50E-03	2.60E-04	7.19E+02	7.19E+02	-	-	-	-
14	cadmium	2.51E-04	6.27E-04	1.41E+01	1.41E+01	2.35E-02	9.40E-04	6.53E+02	4.12E+02	-	-	-	-
14	chromium	1.60E-02	4.00E-02	9.02E+02	9.02E+02	1.50E+00	6.00E-02	1.05E+04	2.63E+04	-	-	-	-
14	copper	6.13E-03	1.53E-02	6.90E+02	6.90E+02	5.75E-01	2.30E-02	4.02E+03	2.01E+04	-	-	-	-
14	manganese	4.80E-01	1.20E+00	5.40E+06	5.40E+06	4.50E+01	1.80E+00	1.58E+05	1.58E+08	-	-	-	-
14	silver	6.40E-04	1.60E-03	1.44E+01	1.44E+01	6.00E-02	2.40E-03	6.64E+03	4.19E+02	-	-	-	-
16	aroclor-1254	2.75E-02	3.10E-04	5.25E-02	8.03E-02	2.58E+00	4.65E-04	1.29E+05	4.11E+00	-	-	-	-
16	aroclor-1260	1.63E-02	1.84E-04	1.30E-02	2.94E-02	1.53E+00	2.76E-04	6.06E+04	1.90E+00	-	-	-	-
16	cadmium	2.40E-04	6.00E-04	1.35E+01	1.35E+01	2.25E-02	9.00E-04	6.26E+02	3.95E+02	-	-	-	-
16	copper	9.33E-03	2.33E-02	1.05E+03	1.05E+03	8.75E-01	3.50E-02	6.11E+03	3.06E+04	-	-	-	-
16	silver	3.15E-04	7.87E-04	7.06E+00	7.06E+00	2.95E-02	1.18E-03	3.27E+03	2.06E+02	-	-	-	-
20	lead	1.33E-02	3.33E-02	2.99E+03	2.99E+03	1.25E+00	5.00E-02	2.76E+05	8.73E+04	-	-	-	-
20	silver	4.00E-04	1.00E-03	8.98E+00	8.98E+00	3.75E-02	1.50E-03	4.15E+03	2.62E+02	-	-	-	-
22A	benzo(a)anthracene	1.47E-04	2.89E-06	3.45E-04	4.94E-04	1.38E-02	4.33E-06	1.31E+00	2.38E-02	-	-	-	-
22A	benzo(a)pyrene	1.04E-04	1.57E-06	6.58E-04	7.64E-04	9.75E-03	2.36E-06	1.88E+00	2.89E-02	-	-	-	-
22A	benzo(b)fluoranthene	1.92E-04	2.62E-06	2.42E-04	4.37E-04	1.80E-02	3.92E-06	8.23E+01	2.51E-02	-	-	-	-
22A	chrysene	1.68E-04	3.31E-06	3.95E-04	5.66E-04	1.58E-02	4.96E-06	5.10E+01	2.73E-02	-	-	-	-
22A	2,3,7,8-TCDD	2.53E-06	3.39E-08	3.84E-06	6.41E-06	2.38E-04	5.08E-08	5.59E+00	3.50E-04	-	-	-	-

Site	Parameter	White-Tailed Deer				American Robin				Raccoons			
		EDIsoil [mg/kg-B Eq(9)	EDIwater [mg/kg-B Eq(10)	EDIfood [mg/kg-B Eq(11)	TDI Eq(8)	EDIsoil [mg/kg-BW Eq(9)	EDIwater [mg/kg-B Eq(10)	EDIfood [mg/kg-BW Eq(11)	TDI Eq(8)	EDIsoil [mg/kg-B Eq(9)	EDIwater [mg/kg-B Eq(10)	EDIfood [mg/kg-BW Eq(11)	TDI Eq(8)
22A	pentachlorophenol	8.53E-04	3 08E-05	4.10E-03	4.98E-03	8 00E-02	4.62E-05	3.14E+01	1.99E-01	-	-	-	-
22A	methylethyl ketone	1.33E-06	1.11E-04	3.95E-03	4.06E-03	1.25E-04	1.67E-04	1.43E-01	1.15E-01	-	-	-	-
22A	phenanthrene	5.60E-05	5.11E-06	6.45E-04	7.06E-04	5.25E-03	7.66E-06	1.19E+01	2.41E-02	-	-	-	-
22A	anthracene	5.33E-05	4.94E-06	6.24E-04	6.82E-04	5.00E-03	7.41E-06	8.75E+00	2.32E-02	-	-	-	-
22A	pyrene	1.57E-04	7.81E-06	1.04E-03	1.21E-03	1.48E-02	1.17E-05	2.76E+01	4.52E-02	-	-	-	-
22A	DDD	3.23E-06	4.70E-08	4.68E-06	7.95E-06	3.03E-04	7.05E-08	4.90E+00	4.39E-04	-	-	-	-
22A	DDE	7.20E-06	1.38E-07	8.48E-05	9.22E-05	6.75E-04	2.07E-07	1.47E+01	3.15E-03	-	-	-	-
22A	DDT	9.60E-06	1.14E-07	1.71E-05	2.68E-05	9.00E-04	1.71E-07	1.40E+01	1.40E-03	-	-	-	-
22A	mercury	6.93E-05	1.73E-04	2.47E+01	2.47E+01	6.50E-03	2.60E-04	7.19E+02	7.19E+02	-	-	-	-
22A	cadmium	2.77E-04	6.93E-04	1.56E+01	1.56E+01	2.60E-02	1.04E-03	7.23E+02	4.56E+02	-	-	-	-
22A	manganese	4.27E-01	1.07E+00	4.80E+06	4.80E+06	4.00E+01	1.60E+00	1.40E+05	1.40E+08	-	-	-	-
22A	silver	4.27E-04	1.07E-03	9.58E+00	9.58E+00	4.00E-02	1.60E-03	4.43E+03	2.79E+02	-	-	-	-
36-Dove Cr.	aldrin	2.05E-04	4.65E-05	4.94E-04	7.46E-04	-	-	-	-	6.42E-04	3.49E-05	3.67E-01	3.68E-01
36-Dove Cr.	aroclor-1248	2.37E-03	2.68E-04	1.89E-03	4.53E-03	-	-	-	-	7.42E-03	2.01E-04	8.44E+01	8.44E+01
36-Dove Cr.	aroclor-1254	2.19E-03	2.47E-04	4.18E-03	6.61E-03	-	-	-	-	6.83E-03	1.85E-04	1.95E+02	1.95E+02
36-Dove Cr.	aroclor-1260	2.53E-04	2.86E-05	2.02E-04	4.84E-04	-	-	-	-	7.92E-04	2.15E-05	1.80E+01	1.80E+01
36-Dove Cr.	cadmium	6.40E-03	1.60E-01	3.61E+02	3.61E+02	-	-	-	-	2.00E-02	1.20E-01	3.18E+02	3.18E+02
36-Dove Cr.	copper	9.87E-03	2.47E-01	1.11E+03	1.11E+03	-	-	-	-	3.08E-02	1.85E-01	1.23E+02	1.23E+02
36-Dove Cr.	lead	1.63E-02	4.07E-01	3.65E+03	3.65E+03	-	-	-	-	5.08E-02	3.05E-01	6.41E+03	6.42E+03
36-Dove Cr.	mercury	6.93E-05	1.73E-03	2.47E+01	2.47E+01	-	-	-	-	2.17E-04	1.30E-03	1.37E+01	1.37E+01
36-Dove Cr.	silver	4.53E-04	1.13E-02	1.02E+01	1.02E+01	-	-	-	-	1.42E-03	8.50E-03	8.96E+01	8.96E+01
36-Dove Cr.	zinc	4.21E-02	1.05E+00	1.89E+04	1.89E+04	-	-	-	-	1.32E-01	7.90E-01	5.25E+03	5.26E+03
36-West Pond	cadmium	1.60E-03	4.00E-02	9.02E+01	9.03E+01	-	-	-	-	5.00E-03	3.00E-02	7.94E+01	7 95E+01
36-West Pond	silver	4.53E-04	1.13E-02	1.02E+01	1.02E+01	-	-	-	-	1.42E-03	8.50E-03	8.96E+01	8 96E+01
36-Lagoon	acetone	1.81E-04	3.64E-01	1.10E+00	1.46E+00	-	-	-	-	5.67E-04	2.73E-01	3.54E-01	6.28E-01
36-Lagoon	aroclor-1248	4.00E-05	4 52E-06	3.19E-05	7.64E-05	-	-	-	-	1.25E-04	3.39E-06	1.42E+00	1.42E+00
36-Lagoon	aroclor-1254	4.80E-05	5.42E-06	9.17E-05	1.45E-04	-	-	-	-	1.50E-04	4.07E-06	4.29E+00	4 29E+00
36-East Pond	methylene chloride	2.13E-04	3.62E-02	1.78E-01	2.14E-01	-	-	-	-	6.67E-04	2.72E-02	4.75E-01	5.03E-01
36-East Pond	acetone	2.35E-04	4.71E-01	1 42E+00	1.89E+00	-	-	-	-	7.33E-04	3.53E-01	4.58E-01	8.12E-01
36-East Pond	methylethyl ketone	4.29E-05	3.58E-02	1.27E-01	1.63E-01	-	-	-	-	1.34E-04	2.68E-02	8.75E-02	1.14E-01
36-East Pond	mercury	8.00E-04	2.00E-02	2.85E+02	2.85E+02	-	-	-	-	2.50E-03	1.50E-02	1.58E+02	1.58E+02
36-East Pond	chromium	5.33E-02	1.33E+00	3.01E+03	3.01E+03	-	-	-	-	1.67E-01	1.00E+00	6.65E+02	6.66E+02
36-East Pond	copper	4.21E-02	1.05E+00	4.74E+03	4.74E+03	-	-	-	-	1.32E-01	7.90E-01	5.25E+02	5.26E+02
36-East Pond	manganese	3.47E-01	8.67E+00	3.90E+06	3.90E+06	-	-	-	-	1.08E+00	6.50E+00	2.17E+03	2.17E+03
36-East Pond	nickel	9.60E-03	2.40E-01	1.08E+02	1.08E+02	-	-	-	-	3.00E-02	1.80E-01	6.00E+01	6.02E+01
36-East Pond	silver	2.88E-02	7.20E-01	6.46E+02	6.47E+02	-	-	-	-	9.00E-02	5.40E-01	5.69E+03	5.69E+03
36-East Pond	zinc	2.13E-01	5 33E+00	9.55E+04	9.56E+04	-	-	-	-	6.67E-01	4.00E+00	2.66E+04	2.66E+04
36-East Pond	2-methylnaphthalene	5.04E-03	1.17E-02	1.30E-01	1.47E-01	-	-	-	-	1.58E-02	8.79E-03	2.86E+00	2.89E+00
36-East Pond	acenaphthene	7.47E-03	1.58E-02	1.76E-01	1.99E-01	-	-	-	-	2.33E-02	1.18E-02	1.53E+01	1.54E+01
36-East Pond	aldrin	8.80E-04	1.99E-04	2.12E-03	3.20E-03	-	-	-	-	2.75E-03	1.49E-04	1.57E+00	1.58E+00
36-East Pond	anthracene	2 51E-03	2.32E-03	2.93E-02	3.41E-02	-	-	-	-	7.83E-03	1.74E-03	7.83E+00	7.84E+00
36-East Pond	antimony	1.04E-02	2.60E-01	1.17E+02	1.17E+02	-	-	-	-	3.25E-02	1.95E-01	2 06E+02	2.06E+02
36-East Pond	aroclor-1248	1.12E-02	1.26E-03	8.92E-03	2.14E-02	-	-	-	-	3.50E-02	9.49E-04	3 98E+02	3.98E+02
36-East Pond	aroclor-1254	2.13E-02	2.41E-03	4.08E-02	6.45E-02	-	-	-	-	6.67E-02	1.81E-03	1 90E+03	1.90E+03
36-East Pond	aroclor-1260	2.08E-03	2.35E-04	1.66E-03	3.97E-03	-	-	-	-	6.50E-03	1.76E-04	1.48E+02	1.48E+02
36-East Pond	benzo(a)anthracene	1.04E-03	2.05E-04	2.44E-03	3.69E-03	-	-	-	-	3.25E-03	1.53E-04	1.77E-01	1.81E-01
36-East Pond	benzo(a)pyrene	3.84E-04	5.80E-05	2.43E-03	2.87E-03	-	-	-	-	1.20E-03	4.35E-05	1.32E-01	1.34E-01
36-East Pond	benzo(b)fluoranthene	1.04E-03	1.42E-04	1.31E-03	2.49E-03	-	-	-	-	3.25E-03	1.06E-04	8.50E+00	8.50E+00
36-East Pond	bis(2-ethylhexyl)phthalate	3.25E-04	1.19E-04	1.56E-03	2.01E-03	-	-	-	-	1.02E-03	8.92E-05	4.01E+00	4.01E+00
36-East Pond	cadmium	7.20E-03	1.80E-01	4.06E+02	4.06E+02	-	-	-	-	2.25E-02	1.35E-01	3.57E+02	3.58E+02
36-East Pond	chrysene	6.96E-04	1.37E-04	1.64E-03	2.47E-03	-	-	-	-	2.18E-03	1.03E-04	4.02E+00	4.02E+00
36-East Pond	dibenzofuran	5.25E-03	8.09E-03	9.58E-02	1.09E-01	-	-	-	-	1.64E-02	6.07E-03	2.73E+01	2.73E+01
36-East Pond	fluoranthene	6.45E-03	2.91E-03	3.90E-02	4.84E-02	-	-	-	-	2.02E-02	2.18E-03	2.90E+01	2.90E+01
36-East Pond	fluorene	1.17E-02	1.65E-02	1.95E-01	2.23E-01	-	-	-	-	3.67E-02	1.23E-02	5.30E+01	5.30E+01
36-East Pond	lead	1.33E-01	3.33E+00	2.99E+04	2.99E+04	-	-	-	-	4.17E-01	2.50E+00	5.26E+04	5.26E+04
36-East Pond	naphthalene	1.63E-03	9.36E-03	8.76E-02	9.86E-02	-	-	-	-	5.08E-03	7.02E-03	9.99E+00	1.00E+01
36-East Pond	phenanthrene	1.33E-02	1.22E-02	1.53E-01	1.79E-01	-	-	-	-	4.17E-02	9.12E-03	5.41E+01	5.41E+01
36-East Pond	pyrene	3.71E-03	1.84E-03	2.46E-02	3.01E-02	-	-	-	-	1.16E-02	1.38E-03	1.24E+01	1 24E+01

1565 ish

Clock

1565
DAR 67

Golder Associates Inc.

1809 North Mill Street, Suite C
Naperville, IL USA 60563
Telephone (708) 357-2066
Fax (708) 357-2330

Golder Associates

TRANSMITTAL LETTER

To: Mark Sattelberg
U.S. Fish + Wildlife Service
Rural Route 3, Box 328
Marion IL

Date: 12/23/93

Project No.: 923-8108.720

VCJZ

Sent by: WGG - Bill Gierke

✓ Regular Mail
✓ Federal Express
____ United Parcel Service
____ Hand Carried

Quantity	Item	Description
1	1	Revised Draft of Preliminary Ecological Risk Assessment

Remarks: Mark, please forward any comments by end of day Thursday, if we want it out by January 3, 1993. Please call to discuss other report.

Per WGG

DEC 28 1993

00000300